A.I.A. File No. 10-C

FACTS ABOUT

CONCRETE MASONRY

WITH CONSTRUCTION DETAILS

AND SUGGESTED SPECIFICATIONS

Published by

NATIONAL CONCRETE MASONRY ASSOCIATION

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NATIONAL CONCRETE MASONRY ASSOCIATION

An Organization of American Concrete Products Manufacturers

33 West Grand Avenue

Chicago

The NATIONAL CONCRETE MASONRY ASSOCIATION is an organization of American concrete products manufacturers working together to improve and extend the uses of concrete masonry* units.

The objects of this ASSOCIATION are: (1) to facilitate the acquirement and interchange of practical knowledge among its members; (2) to encourage the development of the art of manufacturing concrete masonry units; (3) to create a standard of excellence in manufacture; (4) to promote the use of concrete masonry; (5) to arrange and provide for advertising the products of members; (6) to gather data and issue literature of technical as well as promotive character; (7) to exercise a corrective influence on the quality of concrete masonry units to the end that ASSOCIATION standards may be maintained; and (8) to secure more efficient cooperation between the concrete masonry industry and architects, builders, building officials, engineers, owners and others.

This is the eighth edition of "Facts About Concrete Masonry" published by the NATIONAL CONCRETE MASONRY ASSOCIATION, the first being issued in 1932.

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*The term concrete masonry is applied to block, brick or tile building units molded from concrete, and laid by masons in a wall. The concrete is made by mixing portland cement with water and such materials as sand, pebbles, crushed stone, cinders, slag, burned shale or clay or other suitable aggregates.

CONTENTS

Interesting Facts About Concrete Masonry Industry

More than 3,000 established plants produce concrete masonry units in the United States and Canada.

Over $100,000,000 is invested in plants manufacturing concrete masonry units.

Annual production of concrete masonry units increased 400 per cent from 1921 to 1939.

More than 7,000,000 cu. yd. of aggregate is used in a normal year by the concrete masonry industry.

Over 150,000 men are employed by the concrete masonry industry.

More than 30 per cent of all masonry construction is built with concrete masonry units.

FACTS ABOUT CONCRETE MASONRY

CONCRETE masonry is widely used in building construction because of its many definite advantages. It is economical, light in weight, durable, fire-resistive, and able to carry heavy loads. It is regularly used for both load-bearing and non-load-bearing walls, for partitions, as backing for all types of facing materials, for fireproofing, as floor fillers, and for almost every building construction use where masonry can be used advantageously.

The advantages of concrete masonry are not confined to its use as a structural material. It has other desirable properties which have contributed to its rapidly increasing use. It is readily adaptable to any style of architecture. It lends itself to a wide variety of surface finishes for both exterior and interior walls. Concrete masonry made with lightweight aggregates has excellent sound-absorption qualities which make it particularly suitable for building exposed walls in all types of auditoriums, for gymnasiums, for class rooms, for corridors and, in fact, for all buildings where noise abatement or good acoustical properties are sought.

Because of its many inherent advantages, it is not surprising that concrete masonry is enjoying such a wide and increasing use in all types of buildings—schools, churches, auditoriums, theaters, factory buildings, apartments, residences, stores, garages, warehouses, farm buildings of all types, and the full range of building construction from a one-room milk house to a multi-story skyscraper.

What It Is—Its Characteristics

The term "concrete masonry" is applied to block, brick and tile building units molded from concrete and laid by masons in a wall. The concrete is made by mixing portland cement with water and such materials as sand, pebbles, crushed stone, cinders, slag, burned shale or clay or other suitable aggregates.

Sizes and Weights

Concrete masonry units are made in several sizes and shapes. The 8x8x16-in. size laid up in single thickness produces a wall 8 in. thick with courses 8 in. high. One course is equivalent to three brick courses. Units 8 in. high and 16 in. long are also regularly made in the 10 and 12-in. widths. Partitions and veneer units are made in 3, 4 and 6-in. widths. Actual heights and lengths are usually about ¼ to ⅜ in. scant to allow for the thickness of mortar joints. For example, a so-called 16-in. unit is actually only 15⅝ or 15¾ in. long, which, with ⅜ or ¼-in. mortar joint, will occupy exactly 16 in. in the wall. Similarly, the 7¾-in. height plus ¼-in. mortar joint is exactly 8 in. This allowance for mortar joints makes all wall measurements work out to even feet and inches.

Concrete masonry units 12 in. long and 8 in. wide are made in the 5 and 3½-in. heights. Units in these heights are also available in 4, 5 and 6-in. widths. Actual heights run about ¼ in. over these to work out with brick heights. The 5-in. unit is two brick courses high. The 3½-in. unit lays two courses equal to three courses of brick.

The three standard sizes of concrete masonry units, including the specials—corner, joist, jamb and other special units—are shown on page 45. Information on weights and quantities of units, mortar and labor required to build 100 sq. ft. of wall is given in Table 14 on page 28.

Quality

Concrete masonry units made under modern production methods easily meet building code requirements as well as the specifications of the American Society for Testing Materials, Underwriters' Laboratories and the Master Specifications of the United States Government. Strength requirements usually range between 700 and 800 p.s.i.* in compression for load-bearing units. For non-load-bearing (partition) units strength requirements are usually waived. When used in walls exposed to the weather or soil, concrete masonry units are usually required to remain within certain absorption limitations expressed in weight or percentage of water, which must not be exceeded to pass satisfactory test. See Table 19, page 44 for the strength and absorption requirements in the building codes of the larger cities in this country.

Surface Finishes

A variety of interesting wall finishes is available with concrete masonry construction.

At the time of manufacture, a variety of surface textures ranging from a very fine, close texture to a

**p.s.i.—pounds per square inch.*

coarse, open texture may be produced by the proper selection, grading and proportioning of the aggregates. Textures may also be developed by treating the faces of the units while still green by wire brushing or combing, or by slightly eroding the surface by ejecting a fine spray of water upon it. Color may be introduced by incorporating non-fading mineral color pigments in the facing; by applying a colored cement grout or paint to the face of the units immediately after they are removed from the molds; or selected colored aggregates may be used in the facing and exposed by washing with water or dilute muriatic acid.

A recent development in concrete masonry construction known as "concrete ashlar" has greatly increased the number of interesting and attractive wall effects that can be produced with concrete masonry. Additional information on concrete ashlar is given on pages 39 and 40. Several popular concrete ashlar patterns are shown on pages 41 and 71.

Another popular finish for concrete masonry construction is portland cement stucco. Concrete masonry units provide a strong, mechanical key uniting the concrete masonry backing and portland cement stucco finish in a strong, permanent bond. Several popular portland cement stucco finishes are shown on page 41.

CONCRETE MASONRY ON THE JOB

Concrete masonry units lay rapidly because of their size. One 8x8x16-in. block is equal to twelve of brick and mortar. One 5x8x12-in. tile replaces six brick. The special units such as corner, half and quarter sizes, jamb, joist and header units further simplify the job of laying true workmanlike walls.

Wall Thickness

The thickness of walls is usually regulated by building codes. Eight inches is usually specified as the minimum thickness for all exterior walls and for load-bearing interior walls. Partitions and curtain walls are often made 3, 4 or 6 in. thick. The thickness of bearing walls in heavily loaded buildings is properly governed by the limitations of loading. Allowable working loads are commonly 70 p.s.i. of gross wall area when laid in 1:1:6 portland cement-lime mortar and 80 p.s.i. of gross wall area when laid in 1:3 portland cement mortar. The following table of wall thicknesses recommended in the report of the Building Code Committee, United States Bureau of Standards, 1925, applies to residences and buildings up to four stories. In special cases the Bureau of Standards recommends a 12-in. wall throughout in four-story buildings.

TABLE 1—Recommended Thicknesses of Walls of Residences and Buildings up to Four Stories in Height

No. of Stories	Basement	First Story	Second Story	Third Story	Fourth Story
1	12 in.	8 in.			
2	12 in.	8 in.	8 in.		
3	12 in.	12 in.	12 in.	8 in.	
4	16 in.	16 in.	12 in.	12 in.	12 in.

Mortar

A mortar consisting of 1 volume portland cement, not more than 1 volume of lime putty or hydrated lime, and damp, loose mortar sand equal to not more than three times the combined volumes of cement and lime is recommended for ordinary work. When a mortar of maximum strength is desired for use in load-bearing walls, in walls subjected to heavy earth pressure, walls in areas subject to earthquakes, hurricanes or other severe stresses, a mortar consisting of 1 volume of portland cement and not more than 3 volumes of damp, loose mortar sand, to which plasticizing agents may be added, is recommended.

Construction Details

In the following pages will be found information showing the best accepted practice in building with concrete masonry, including practically all conditions which will be met in ordinary building construction. From these details it is expected that the architect or builder will be able to fit together various combinations which may be best suited for the type of building to be erected. Any of the several types of floors and roofs shown may be used with either block or tile walls. In like manner, any type of wall finish—plain concrete masonry, painted concrete ashlar or portland cement stucco—can be used interchangeably with the different types of walls, floors and roofs.

This publication also presents authoritative data pertaining to other qualities of concrete masonry walls. The facts dealing with the comparative strength, fire resistance and other properties of concrete masonry and other forms of masonry walls will give architects, builders, building officials, engineers, owners and others the true picture of concrete masonry.

**The amount of plasticizing agent required will vary with the kind of agent used, the grading of the sand, and other factors. Use the minimum quantity which will produce the desired workability. The kind of plasticizing agent to be used and the amount should be specified by the architect or owner in advance of starting construction.*

Principal Factors Affecting Strength of Masonry Walls

THE factors which govern the strength and other desirable qualities of masonry walls have been determined through years of scientific study and a considerable amount of research work. A study of these factors has developed what are known as *allowable working loads* on masonry walls. Therefore, in addition to listing the principal factors which affect the strength of masonry walls, this section also includes facts on allowable working loads.

What are the factors which affect the strength of masonry walls?

There are eight principal factors, namely:

(1) **Strength of Unit**—Concrete masonry units having a compressive strength of 700 p.s.i., when laid in strong mortar, will produce stronger walls than units having a compressive strength of only 400 p.s.i., laid in similar mortar. This relation also holds for other types of masonry.

(2) **Design of Unit**—The design of the unit determines the area available for mortar bedding and the alignment of the face shells and webs, all of which affect wall strength.

(3) **Regularity of Unit**—Units that are true in size and shape are readily aligned in the wall both horizontally and vertically, thus providing exact alignment of bearing areas and uniform mortar joints. These are essential in building strong walls. Irregular mortar joints cause irregular stresses which tend to decrease wall strengths.

(4) **Size of Unit**—The size of the unit governs the number of mortar joints. The more joints there are, the greater the chance for variation in workmanship and bedding. Such variation may result in lowered wall strengths.

(5) **Strength of Mortar**—No chain is stronger than its weakest link. To develop maximum wall strength, the mortar in the joints should be at least as strong as the masonry units. Mortar may be stressed to over 2000 p.s.i. under concentrated loadings, as in piers or when shock or other unexpected loads must be resisted. Therefore, the strength of the mortar is an important factor in building strong walls.

(6) **Bond of Mortar to Unit**—In masonry, a strong mortar bond is necessary to resist possible failures from such causes as vibration, violent wind storms and earthquakes. The value of strong mortars was forcefully demonstrated in the Florida hurricanes of 1926 and 1928 when weak mortars frequently failed in bond, whereas there were few failures in sections such as Coral Gables where a 1:1:6 portland cement-lime or stronger mortar was specified and actually used.

(7) **Thickness of Mortar Joint**—In general, the thinner the mortar joint the stronger the masonry wall. Regular, true units, like concrete masonry units, make it possible to obtain uniform, thin joints with resulting high wall strengths.

TABLE 2—Strength Specifications for Concrete Masonry Units

Specification and Year Adopted	Face Shell Thickness	Compressive Strength Gross Area p.s.i.
A.S.T.M. (1939)	1¼ in. or over	700
	¾ in. to 1¼ in.	1000
Federal (1931)	1¼ in. or over	700
	¾ in. to 1¼ in.	1000
Underwriters' (1939)	1¼ in. or over	700

(8) **Quality of Workmanship**—Good materials will not compensate for inferior workmanship. Good workmanship is essential in building strong walls. On the quality of the workmanship depends the completeness with which the units are bedded, the alignment of the units, the thickness of the mortar joints, as well as other factors which affect wall strength.

What are the strength requirements for concrete masonry units in representative specifications?

Specifications of American Society for Testing Materials (A.S.T.M.), Federal Specifications' Board and Underwriters' Laboratories, Inc., are the same for units with minimum face shell thickness of 1¼ in. or more, namely, an average compressive strength of not less than 700 p.s.i. over the gross area of the unit as laid in the wall. For units with face shell thickness from ¾ to 1¼ in., A.S.T.M. and Federal specifications require a strength of 1000 p.s.i. Representative strength specifications are listed in Table 2.

What maximum loadings do building codes permit on concrete masonry walls and how do they compare with the allowable loadings on structural clay tile and on clay brick walls?

There is some variation in the allowable loads, as may be seen in Table 19 on page 44. The allowable loads on masonry walls permitted in the U. S. Department of Commerce and The National

Board of Fire Underwriters building codes are shown in Table 3. Note that the maximum allowable loading for both concrete masonry and structural clay tile is 70 p.s.i. when the walls are laid with portland cement-lime mortar, and is increased to 80 p.s.i. when laid with portland cement mortar.

TABLE 3—Allowable Loads on Masonry Walls (p.s.i.)

Building Code	Concrete Masonry		Structural Clay Tile		Brick*	
	Portland Cement Mortar	Portland Cement-Lime Mortar	Portland Cement Mortar	Portland Cement-Lime Mortar	Portland Cement Mortar	Portland Cement-Lime Mortar
Dept. of Commerce Bldg. Code Comm. 1931	80	70	80	70	175	140
National Board of Fire Underwriters 1931	80	70	80	70	175	140

**2500-p.s.i. Brick, Clay, Concrete, Sand-Lime.*

Other Allowable Loadings

For brick, having a compressive strength of at least 2500 p.s.i., the allowable loading is 140 p.s.i. for portland cement-lime mortar and 175 p.s.i. for portland cement mortar. In each case the allowable loading for walls laid in portland cement mortar is greater than for walls laid with portland cement-lime mortar. The U. S. Department of Commerce and The National Board of Fire Underwriters codes are widely used in drafting building codes because they are representative of best construction practice and serve as examples of well-considered codes, free from the effects of local peculiarities or prejudices.

TABLE 4—Typical Factors of Safety

Material	Ultimate Strength p.s.i.	Allowable Stress p.s.i.	Factor of Safety
Concrete (walls)	3,000	600	5.0
Reinforcing Steel (tension)	70,000	20,000	3.5
Structural Steel	55,000	18,000	3.0

Why do specifications require a compressive strength of 700 p.s.i. and then limit loading to 70 or 80 p.s.i.?

To provide what is known as "a factor of safety" is the reason. To make certain that there will be no structural failures due to overloading, building codes limit the loading to a figure considerably below the strength of the material in the wall. This also takes care of unusual and unexpected loads, variation in materials and workmanship, etc. Table 4 gives typical factors of safety for cast-in-place concrete, reinforcing steel and structural steel. Note that the ultimate strength is from three to five times greater than the allowable stress. The factor of safety is then the ultimate strength of the material divided by the allowable working load.

Factor for Masonry Walls

For concrete masonry walls, the commonly accepted factor of safety is 4—that is, the wall must be at least four times as strong as the maximum permissible loading. Thus, a wall with an allowable loading of 80 p.s.i. must have a strength of at least 4 times 80 or 320 p.s.i. For an allowable loading of 70 p.s.i., a wall strength of at least 280 p.s.i. is required. A factor of safety of 4 is used in all discussions of wall strengths in this publication.

OUTSTANDING FACTS

Principal factors which govern the strength of masonry walls are (1) strength of unit, (2) design of unit, (3) regularity of unit, (4) size of unit, (5) strength of mortar, (6) bond of mortar to unit, (7) thickness of mortar joint, and (8) quality of workmanship.

Representative specifications usually require that load-bearing concrete masonry units have a minimum compressive strength of 700 p.s.i., gross area.

A.S.T.M. and Federal specifications require a minimum compressive strength of 700 p.s.i. for concrete masonry units with face shells 1¼ in. or more in thickness.

For concrete masonry units with face shells ¾ to 1¼ in. thick, A.S.T.M. and Federal specifications require a compressive strength of 1000 p.s.i.

The usual working load for concrete masonry is 70 p.s.i., when laid in portland cement-lime mortar; 80 p.s.i., when laid in portland cement mortar.

The allowable working load on clay tile walls usually is the same as for concrete masonry walls.

The usual factor of safety for masonry walls of all types is 4.

Strength and Stability of Concrete Masonry Walls

(Abstract of Data from University of Illinois and Portland Cement Association Tests)

COMPLETE authoritative data on the strength of concrete masonry walls are available to the concrete masonry industry from comprehensive tests conducted at the University of Illinois through cooperation of the National Concrete Masonry Association, the Portland Cement Association and the University, as well as from additional tests made in the Research Laboratory, Portland Cement Association.

University of Illinois Tests

In the University of Illinois tests, 60 full size walls, 9 ft. 6 in. high and 6 ft. wide, and 42 small walls (wallettes), 4 ft. high and 2 ft. 8 in. wide, were built and tested. These tests included three designs of concrete masonry units, five types of aggregate and two different mixtures of mortar. There was a variation from 550 to 1570 p.s.i. in the compressive strength of the units and a range of wall strengths from 330 to 780 p.s.i.

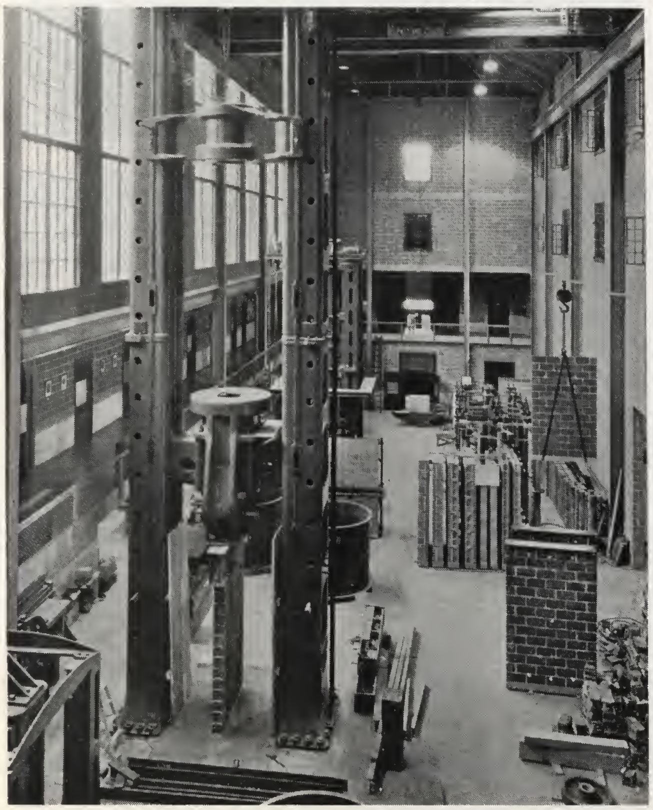


Fig. 1. Main bay, Testing Materials Laboratory, University of Illinois. Large testing machine at left, in which concrete masonry walls were tested, has capacity of 3,000,000 lb.

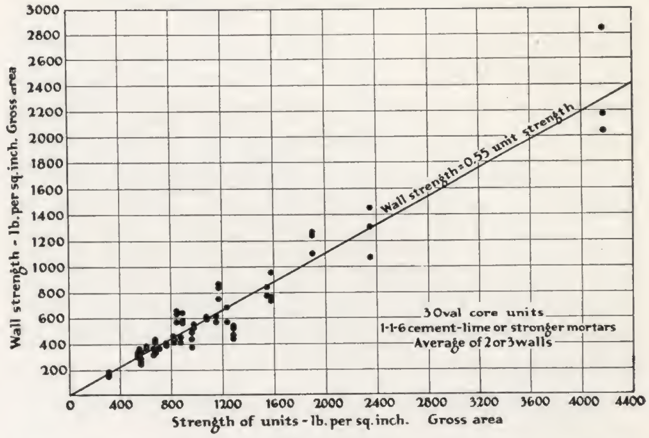


Fig. 2. Strength relation of concrete masonry walls to units, full mortar bedding. Data from University of Illinois and Portland Cement Association tests.

Portland Cement Association Tests

Tests in the Research Laboratory, Portland Cement Association, were made on 108 wallettes. Since this investigation was to determine effect of mortar strength and strength of unit on the strength of concrete masonry walls, it included six different mortar mixtures ranging from 1:3 lime to 1:2 portland cement mortar with a range in strength from 150 to 4780 p.s.i. The concrete masonry units likewise were made to obtain a wide variation in unit strengths and ranged from 320 to 4180 p.s.i. The walls showed a range in strength from 145 to 2880 p.s.i.

What is the relation between strength of units and the strength of walls?

For concrete masonry units laid with full mortar bedding in 1:1:6 portland cement-lime or stronger mortar, the wall strength is 55 per cent of the unit strength. Fig. 2 shows the combined results of the tests at the University of Illinois and in the Research Laboratory, Portland Cement Association. The strength of the units is plotted horizontally and the strength of the walls is plotted vertically. Each point represents the average strength for two or three walls. The average line gives the relation —that is, wall strength equals 55 per cent of the strength of the unit.

Concrete masonry units having a strength of 700 p.s.i. produced walls having a strength of approximately 385 p.s.i. Units of 800 p.s.i. strength produced walls having a strength of 440 p.s.i.

How can results of the University of Illinois tests be combined with those made in the Research Laboratory of the Portland Cement Association when only wallettes were used in making the latter tests?

In the University of Illinois tests it was found that there was a definite relation between the strength of large walls and the strength of small walls. This relation is expressed by an equation—that is, large wall strength equals 91 per cent of the strength of wallettes. Knowing this relation to be true, it is possible to test small walls and then compute what the results would be for full story-height walls. This is done by multiplying the small wall results by 0.91. This method was used in plotting the curve in Fig. 2.

How strong can concrete masonry walls be built?

Fig. 2 shows that extremely strong concrete masonry walls can be built. The strongest units in these tests averaged 4180 p.s.i. and produced an average wall strength above 2300 p.s.i. With a factor of safety of 4, such walls would be permitted a working load of 550 p.s.i., or more than three times the maximum working load recommended by the Building Code Committee, U. S. Department of Commerce, on 2500-p.s.i. brick laid up in portland cement mortar, and almost seven times as high as the maximum load (80 p.s.i.) permitted on walls of hollow masonry units.

What factor of safety is obtained with units having a strength of 700 p.s.i. where the maximum allowable load is 70 p.s.i.?

Using the relation that wall strength equals 55 per cent of the strength of the unit, it is first determined that wall strength equals 0.55 times 700, or 385 p.s.i. Dividing 385 by 70 gives a factor of safety of approximately 5.5, which is well over the factor of safety of 4 generally required. Another method is to refer to the curve in Fig. 2 to find what wall strength is produced with 700-p.s.i. strength units and then dividing this wall strength by 70.

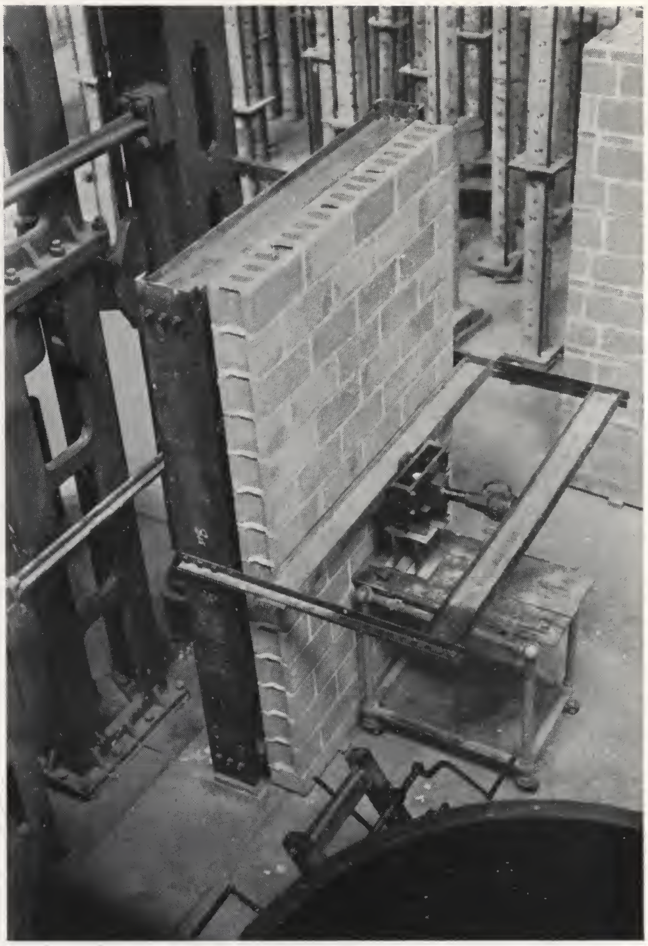


Fig. 3. Concrete masonry wall being tested for flexural strength, University of Illinois. Wall is supported against steel frame, transverse load being applied at mid-point with screw-jack on steel I-beam. Dynamometer between jack and beam records load.

IMPORTANT FACTS FROM RECENT TEST DATA

Comprehensive tests at University of Illinois and Research Laboratory, Portland Cement Association, have made available complete information on the strength of concrete masonry walls.

Concrete masonry units laid in portland cement-lime or stronger mortar, with full mortar bedding, produce walls which develop unusually high strengths.

Seven-hundred-pound concrete masonry units, laid in portland cement-lime or stronger mortar, fully bedded, produce walls having strength of 385 p.s.i., and the factor of safety is 5.5 with working load of 70 p.s.i.

Walls of exceptionally high strengths can be built with concrete masonry units. For example, a wall testing as high as 2300 p.s.i. was used in making recent tests. With 80-p.s.i. working load, this wall had a factor of safety of over 28, or seven times the factor 4 required for good construction.

Comparative Wall Strengths: Concrete Masonry and Clay Tile

Which are stronger—concrete masonry or clay tile walls?

Before comparing strengths it is well to examine the A.S.T.M. strength classification for load-bearing clay tile, as given in Table 5, and for concrete masonry.

For LBX tile (end construction), the strength requirement is 1400 p.s.i.; for side construction, 700 p.s.i.* These requirements are based on tests which showed that end construction clay tile must be twice as strong as side construction clay tile to obtain walls of approximately equal strength. It will be recalled that the A.S.T.M. requirement for concrete masonry is 700 p.s.i. (See Section 2.)

Data on Clay Tile Walls

The curves in Fig. 5 show the relation of wall strength to unit strength for both end and side construction clay tile. These curves were plotted from data in U. S. Bureau of Standards, *Technologic Paper 311*, and cover tests on 25 walls, all of which were laid in a somewhat richer mortar than was used in the University of Illinois and Portland Cement Association tests on concrete masonry walls. Strengths of units are plotted horizontally; strengths of walls, vertically. Side construction clay tile units with 350-p.s.i. strength gave wall strengths of about 230 p.s.i. Units of 860-p.s.i. strength gave wall strengths of 390 p.s.i. Units of 1740-p.s.i. strength gave wall strengths of 500 p.s.i.

The strength values for end construction tile are shown by the black dots near the lower curve. There were no tests for full mortar bedding end construction clay tile with strengths less than 1830 p.s.i. End construction clay tile units of 1830-p.s.i. strength gave wall strengths of 460 p.s.i.; 2840-p.s.i. strength end construction tile gave wall strengths of 550 p.s.i. Side construction tile of 800-p.s.i. strength gave wall strengths of approximately 400 p.s.i. A study of the curves shows that 800-p.s.i. side construction tile gave approximately the same wall strengths as 1600-p.s.i. end construction tile.

Facts for Comparing Strengths

The foregoing facts provide the necessary information to compare the strengths of concrete masonry and clay tile walls. Comparing concrete masonry with end construction clay tile, note that a 1400-p.s.i. clay tile gave a wall strength of 340

**End construction clay tile are laid with cores vertical; side construction, with cores horizontal.*

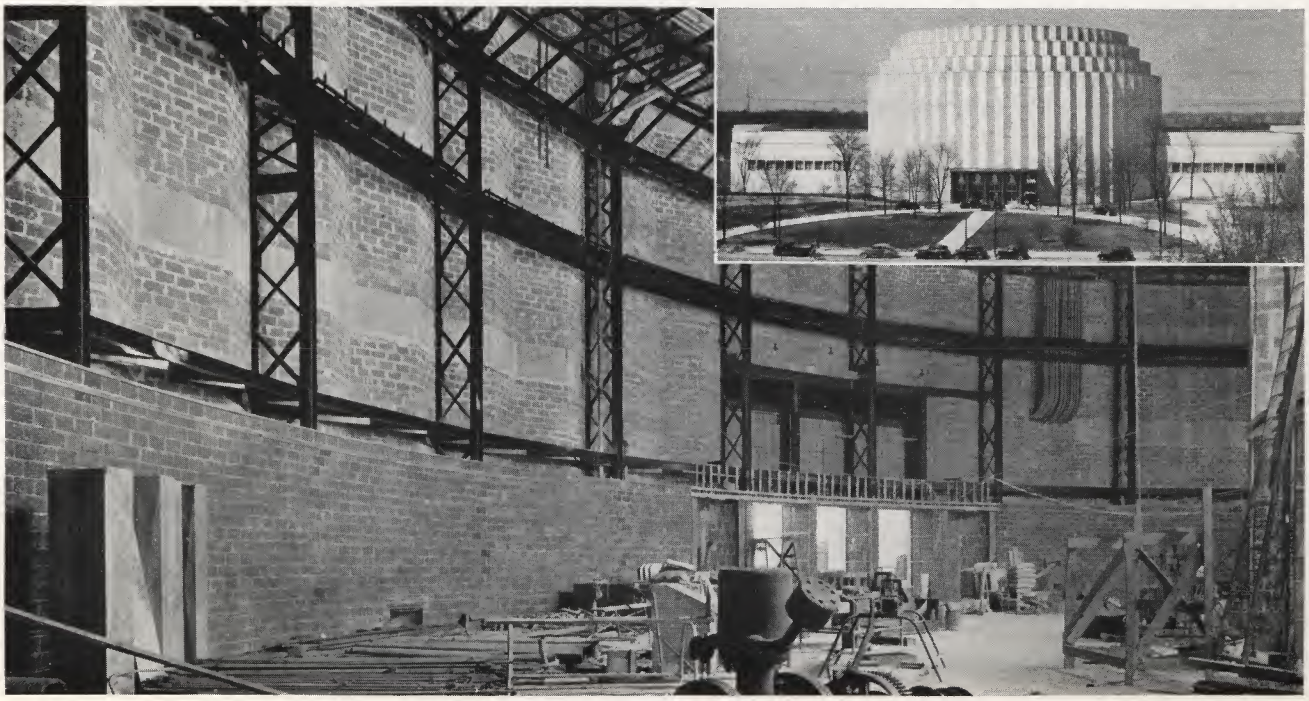


Fig. 4. Ford Courtesy Building, Dearborn, Mich. After careful investigation of all materials, Ford engineers decided to use concrete masonry. Nearly 200,000 units went into the construction of this show place.

p.s.i. and that a concrete masonry unit with a strength of 700 p.s.i. gave a wall strength of 385 p.s.i. The factors of safety, using 70 and 80-p.s.i. working loads, are 4.9 and 4.3 for end construction clay tile; 5.5 and 4.8, for concrete masonry. These two strengths, 1400 p.s.i. for clay tile (end construction) and 700 p.s.i. for concrete masonry, are the minimum strengths generally provided for load-bearing units in building codes. The curves in Fig. 5 show that, with full mortar bedding, concrete masonry units of the same strength as end construction clay tile will produce walls more than twice as strong as clay tile. Here is definite proof that building code requirements for strength of clay tile units, end construction, should be at least twice as high as the strength requirements for concrete masonry.

TABLE 5—Strength Specifications for Structural Clay Load-Bearing Wall Tile

(From A.S.T.M. Specification, Serial Designation C34-36)

Classification*	Minimum Average Compressive Strength Gross Area p.s.i.	
	(End)	(Side)
LBX	1400	700
LB	1000	700

**LBX grade usually required for load-bearing walls.*

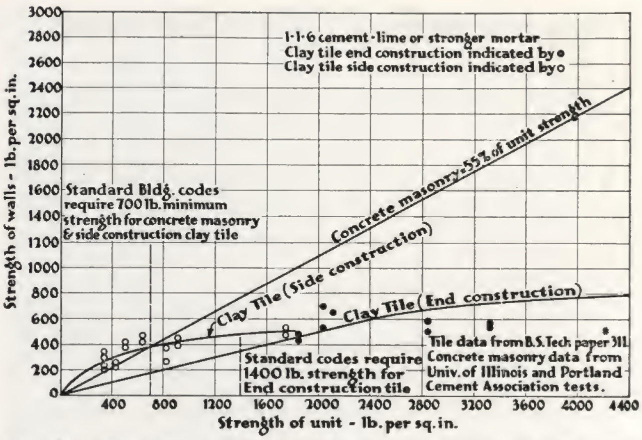


Fig. 5. Strength relation of concrete masonry and clay tile walls to units, full mortar bedding.

How to Use Fig. 5

To examine the relative strength of side construction clay tile walls and concrete masonry walls, note the relation shown in Fig. 5. For 700-p.s.i. units, which is the minimum strength requirement in standard building codes, the wall strength of clay tile and concrete masonry is practically the same. For unit strengths above 700 p.s.i., concrete masonry walls are stronger than side construction clay tile, the difference becoming constantly greater as units of higher strength are used.

OUTSTANDING COMPARISONS BETWEEN STRENGTH OF CONCRETE MASONRY AND CLAY TILE WALLS

Concrete masonry produces walls having about twice the strength of end construction clay tile walls when built with units of the same compressive strength.

Concrete masonry units with 700-p.s.i. strength will produce walls as strong as can be built with 1400-p.s.i. end construction clay tile.

With units testing more than 700 p.s.i., concrete masonry produces stronger walls than side construction clay tile.

Concrete masonry wall strength is approximately 55 per cent of unit strength.

The relation of clay tile wall strength is not constant, but decreases as the unit strength increases.

The strength of end construction clay tile walls is about 25 per cent of the unit strength with a 1400-p.s.i. unit, about 22 per cent with a 3200-p.s.i. unit.

The strength of side construction clay tile walls is about 55 per cent of the unit strength with a 700-p.s.i. unit, about 34 per cent with a 1400-p.s.i. unit.

Comparative Wall Strengths: Concrete Masonry and Clay Brick

How do concrete masonry walls compare in strength with clay brick walls?

In discussing this question, it is well to bear in mind the American Society for Testing Materials' strength requirements for clay brick. These are shown in Table 6. The majority of building codes require that for exposed masonry the brick shall meet the A.S.T.M. specifications for "Grade B" brick, the minimum strength requirement of which is 2500 p.s.i.

Fig. 6 shows the strength relation of concrete masonry walls to units; also a similar relation for clay brick walls to units. The concrete masonry curve is based on tests at the University of Illinois and in the Research Laboratory, Portland Cement Association. The clay brick curve is based on tests made by the U.S. Bureau of Standards and reported in *Research Paper No. 108*, "Compressive Strength of Clay Brick Walls," by Stang, Parsons and McBurney.

Both the concrete masonry and clay brick walls were laid in 1:1:6 portland cement-lime or stronger mortar, the concrete masonry walls having full mortar bedding and the clay brick walls full spread mortar bedding. Spread mortar bedding gives uniformly higher strengths than the furrowed mortar bedding commonly used.

Brick, with unit strength of 2500 p.s.i., gave a wall strength of about 710 p.s.i. Generally, the allowable working load for brick walls is from 140 to 175 p.s.i. With the lower working stress, the factor of safety is 710 divided by 140 or 5.1; with the higher working stress, the factor of safety is 4.1. Concrete masonry units testing 700 p.s.i. have a wall strength of 385 p.s.i., and the wall is allowed a working load of 70 or 80 p.s.i., depending on the kind of mortar used. With the lower working stress, the concrete masonry has a factor of safety of 5.5; with higher loadings, 4.8.

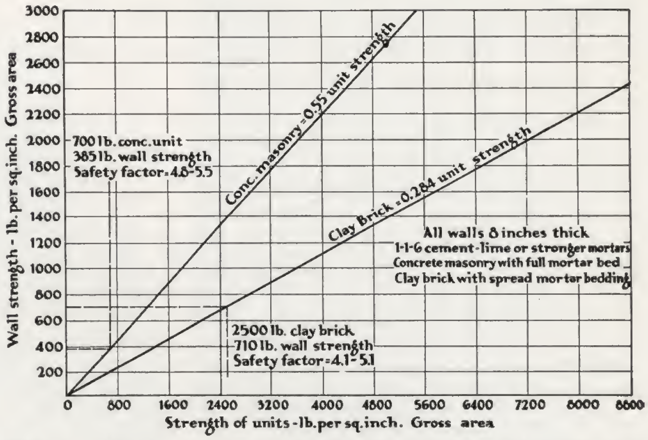


Fig. 6. Comparative strengths of concrete masonry and clay brick walls.

The curves in Fig. 6 show that 2500-p.s.i. clay brick produce a wall strength of about 710 p.s.i. Thirteen-hundred-pound per square inch concrete masonry units will produce the same wall strength. This relation also holds for higher strength units.

TABLE 6—Strength Specifications for Clay Brick

(From A. S. T. M. Specifications, Serial Designation C62-30)

Name of Grade	Compressive Strength (brick flatwise) p.s.i., mean gross area	
	Mean of 5 tests	Individual Minimum
Grade A	4500 or over	3500
Grade B	2500-4500	2000
Grade C	1250-2500	1000

OUTSTANDING COMPARISONS

With usual allowable loads, walls built with 700-p.s.i. concrete masonry units have a higher factor of safety than walls built with 2500-p.s.i. clay brick.

Concrete masonry walls are about twice as strong as clay brick walls built with units of approximately the same strength.

To produce walls of equal strength, clay brick units must be about twice as strong as concrete masonry units.

Concrete masonry wall strength is approximately 55 per cent of unit strength.

Clay brick wall strength is about 28 per cent of unit strength.

Strength of Composite Walls: Concrete Masonry and Face Brick

What strengths are developed with composite walls of face brick and concrete masonry back-up?

The University of Illinois tests* developed definite information on the strength of composite walls. Ten large walls (9 ft. 6 in. high by 6 ft. long) and six small walls (4 ft. high by 2 ft. 8 in. long) were tested in compression. The test walls were 12 in. thick, consisting of a 4-in. brick facing and 8-in. concrete masonry backing.

Summary of Tests

Results of these tests are summarized in Table 7. The second and third columns give the compressive strength of the concrete masonry back-up units; also the compressive strength of the concrete header units. The fourth column gives the average wall strength in p.s.i. for each pair of walls. The right-hand column is the factor of safety on the basis of a 70-p.s.i. working load permitted for composite walls laid with portland cement-lime mortar.

TABLE 7—Strength of Composite Walls†
(Face Brick and Concrete Masonry Back-Up)

Wall No.	Strength of Concrete Masonry Units p.s.i. (Plain)	(Header)	Average Strength of Walls p.s.i.	Factor of Safety‡
16HF	990	710	685	9.8
16HS	720	520	545	7.8
17CF	810	1050	805	11.5
C	805	——	700	10.0
D	720	——	650	9.3

†*1:1¼:4½ portland cement-lime mortar; 12-in. walls.*
‡*Based on 70-p.s.i. working load.*

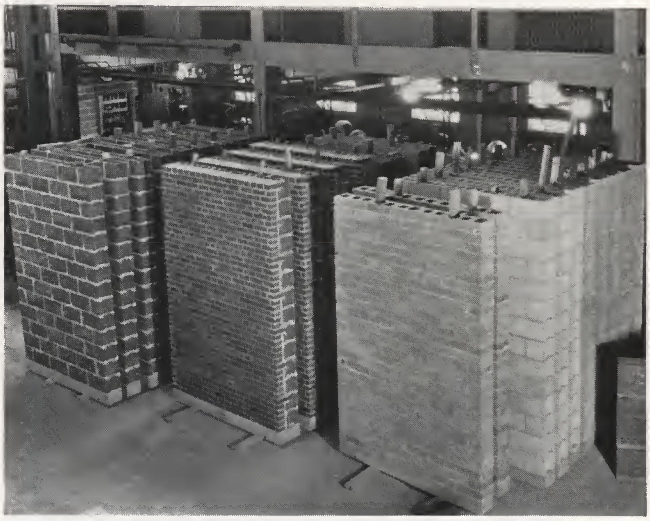


Fig. 7. Concrete masonry walls in storage, University of Illinois investigation. Note composite walls, built with face brick and concrete masonry, in center.

Factors of Safety

The lowest factor of safety obtained was 7.8. The average factor of safety for all groups was 9.6, or more than twice the factor of 4, which is generally required for masonry wall construction. Good inter-action was developed between the brick facing and the concrete masonry backing in the University of Illinois tests—that is, the facing and the backing acted together in carrying the load. Strengths of composite walls tested at the University of Illinois are given in Table 7.

*"*Tests of the Stability of Concrete Masonry Walls,*" by F. E. Richart, P. M. Woodworth and R. B. B. Moorman,* 1931 Proceedings, *American Society for Testing Materials, Vol. 31, Part II, pg. 687.*

IMPORTANT FACTS

Concrete masonry provides satisfactory backing for face brick as evidenced by results of tests conducted at the University of Illinois.

The combination of face brick and concrete masonry backing produces walls having more than double the factor of safety, 4, considered adequate for good construction.

Under heavy loads, there is good inter-action in composite walls of face brick with concrete masonry back-up.

Strawbridge & Clothier branch at Ardmore, Pa. Concrete masonry used as back-up for limestone exterior as well as exterior column fireproofing.

Concrete masonry units were chosen for the walls of this garage at Rumford, Maine.

Architects for Southwestern Bell Telephone Co. Building, Kansas City, Mo., chose light-weight concrete masonry units as the most suitable material for back-up and partitions.

Finished with portland cement stucco, this concrete masonry building houses the Knowlton Creamery of San Antonio, Texas.

Effect of Mortar Bedding and Mortar Strength on Strength of Masonry Walls

To what extent is the strength of masonry walls affected by the mortar bedding?

No wall is stronger than its mortar joints. The amount of bedding area is important because the greater the area provided for mortar bedding, the stronger the wall. Full mortar bedding results in a stronger wall than face shell bedding, as the load is distributed over a greater area. The design of the unit also is an important factor, as it governs the bedding area, the shell and web thickness of the units, and their alignment in the wall.

Fig. 8 summarizes the effect of different methods of mortar bedding on the strength of masonry walls. The upper left-hand curves show the relation between full bedding and face shell bedding for concrete masonry walls laid up in 1:1:6 portland cement-lime or stronger mortar. For full mortar bedding, the wall strength is 55 per cent of the strength of the units; for face shell bedding it is 42 per cent. It will be seen from Table 8 that with full bedding an appreciably larger percentage of the gross area of the unit is covered with mortar than with face shell bedding.

The relation between full and face shell bedding, for clay tile walls is shown in the lower left-hand curves.* These are for end construction clay tile laid in 1:1:6 portland cement-lime or stronger mortar. Walls with face shell bedding are weaker than with full bedding.

In the lower right-hand curves, the strength relation between clay brick walls laid with spread mortar bedding and furrowed mortar bedding is shown.** For the spread bedding, the wall strength was about 28 per cent of the strength of the units; for the furrowed bedding, around 22 per cent. This is about the same percentage of reduction as between full bedding and face shell bedding, for concrete masonry and clay tile walls.

The upper right-hand curves show a graphical application of data presented by Douglas E. Parsons in his paper, "Specifications for Hollow Masonry Building Units."*** Mr. Parsons, of the U. S. Bureau of Standards, has developed from results of tests a formula with which the strength of end construction clay tile walls can be approximately determined. This formula is $M=b\sqrt{mu}$, where M is the strength of the wall in lb. per sq. in., gross area; b is the ratio of bedded area to gross area; m is the strength of the mortar and u is the strength of the unit in p.s.i., gross area. The curves are based on the formula with mortar strength assumed as 1000 p.s.i. which is approximately equal to a 1:1:6 portland cement-lime mortar.

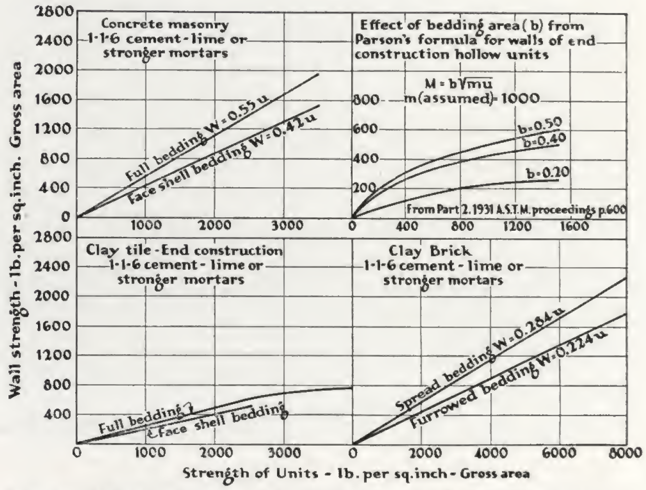


Fig. 8. Effect of mortar bedding area on strength of concrete masonry, clay tile and clay brick walls.

In the lower curve the value b equals 0.20—that is, the units have only 20 per cent of their gross area bedded in mortar. A 700-p.s.i. clay tile will give a 175-p.s.i. wall strength; a 1400-p.s.i. clay tile, a 240-p.s.i. wall strength. When the bedded area is increased to 40 per cent ($b=0.40$) of the gross area, a 700-p.s.i. clay tile will give a wall strength of approximately 340 p.s.i.; 1400-p.s.i. tile, a wall strength of around 470 p.s.i. While this formula is not advanced by Mr. Parsons as applying exactly under all conditions, it clearly illustrates the importance of mortar bearing area on the strength of end construction clay tile walls.

What are the comparative bearing areas of concrete masonry and clay tile units?

This information is given in Table 8 for several types of concrete masonry units and for several types of end construction clay tile. Note that for both full and face shell bedding, concrete masonry units generally provide a larger percentage of bearing area than end construction clay tile. This doubtless accounts in a large measure for the superior strength of concrete masonry walls.

**Based on data from U. S. Bureau of Standards* Technologic Paper 311.

***Based on data from U. S. Bureau of Standards*, Research Paper No. 108.

***1931 Proceedings, *American Society for Testing Materials, Vol. 31, Part II.*

How strong should the mortar be?

Construction with face shell bedding requires a stronger mortar than with full bedding, as there is less area of mortar to carry the load. For example, in full mortar bedding, where 60 per cent of the gross area of the unit may be bedded, the unit stress under a loading of 70 p.s.i. on the wall is 118 p.s.i. To provide a factor of safety of 4, the mortar should have a strength of at least 4 times 118 or 472 p.s.i. This strength can be obtained with a 1:1:6 portland cement-lime mortar.

Using the same units with face shell bedding, where the bedded area is 45 per cent of the gross area of the unit, the stress under a 70 p.s.i. load on the wall is increased to 157 p.s.i. which, with a factor of safety of 4, would require a mortar strength of 628 p.s.i.

Assuming that the bedding area is but 28 per cent or less of the gross area, as it frequently is with end construction clay tile, then a 1000 p.s.i. or stronger mortar is required. This strength can be obtained with a 1:1:4 portland cement-lime mortar.

In general, mortars weaker than a 1:1:6 portland cement-lime mortar should not be used for masonry construction.

TABLE 8—Mortar Bedding Areas

(Common Designs of Concrete Units and Clay Tile)

Description of Unit	Face Shell Thickness (in.)	Mortar Bedding Area Per Cent of Gross Area: Full	Mortar Bedding Area Per Cent of Gross Area: Face Shell
Concrete Units			
3-oval core, 8x8x16-in.	1¾	66	51
3-oval core, 8x8x16-in.	1½	60	45
3-oval core, 8x8x16-in.	1¼	52	38
2-square core, 8x8x16-in.	2⅛	59	54
2-square core, 8x8x16-in.	1¾	50	46
2-square core, 8x5x12-in.	1	40	29
2-square core, 8x3½x12-in.	1¾	58	50
Clay Tile—End Construction			
6-cell, 8x12x12-in.	¾	28	19
9-cell, 8x12x12-in.	¾	38	19
6-cell, double shell 8x12x12-in.	½+½	31	25
Heath cube, 8x8x8-in.	¾	61	19

IMPORTANT FACTS ABOUT MORTAR BEDDING AND STRENGTH

Full mortar bedding produces stronger walls than face shell bedding.

In clay brick wall construction, spread bedding produces stronger walls than the furrowed bedding commonly used.

The greater the mortar bedding, the stronger the masonry wall.

Concrete masonry units, having larger mortar areas than most types of end construction clay tile, consequently produce stronger walls.

A 1:1:6 portland cement-lime or stronger mortar should be used for all masonry wall construction.

Strength of Concrete Masonry Walls After Fire Exposure

How strong are concrete masonry walls after having been in a severe fire?

Numerous tests on concrete masonry walls at Underwriters' Laboratories, Inc. and the Research Laboratory, Portland Cement Association, have developed considerable information regarding both fire retardant properties of concrete masonry walls and their strength after fire exposure.

How Fire Tests Are Made

Underwriters' Laboratories' tests, which are nationally recognized for their impartial findings, are made in accordance with the specifications of the American Society for Testing Materials. Walls of concrete masonry 10 ft. wide by 11 ft. high are built in a frame which is placed in a gas-fed furnace with jets at regular intervals, enabling the testing engineers to maintain uniform temperatures on the wall panel. Within 5 min. after the gas is lighted, the temperature on the exposed face

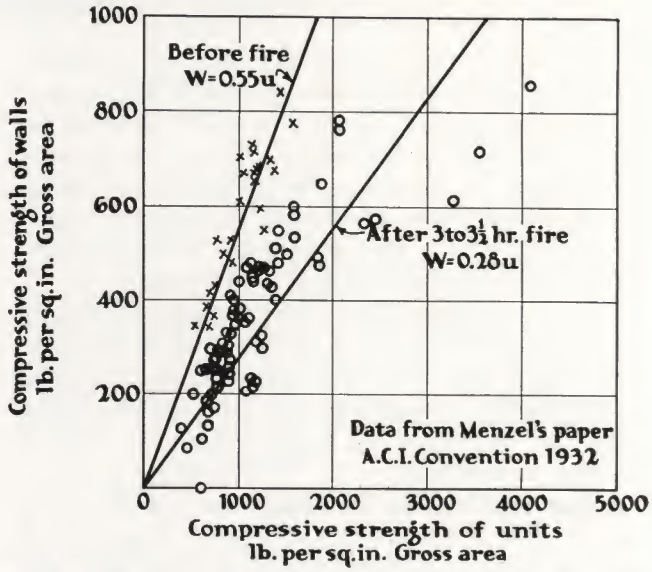


Fig. 10. Strength of 8-in. concrete masonry walls before and after 3 to 3½-hr. fire exposure.

(furnace side) of the panel is 1000 deg. F. At the end of 1 hr., the temperature is 1700 deg. F. Then the temperature is uniformly increased until 1925 deg. is reached at the end of 3 hr. At this time, the exposed face is in a white-hot, incandescent condition.

Throughout the test, accurate temperature measurements are taken on the outer or unexposed face of the panel. When the temperature of the unexposed face has risen 250 deg. the fire exposure part of the test is finished.

During the entire time the panel is in the furnace, a load of 80 p.s.i., the maximum working load allowed in most building codes for hollow masonry walls laid in portland cement mortar, is imposed on the wall.

The concrete masonry walls also are given the fire and hose stream test. In this test, a concrete masonry wall similar in all respects to a wall which is given the full 3-hr. fire endurance test is placed in the furnace, withdrawn after 1 hr. fire exposure, and immediately subjected to the impact, erosion and cooling effects of a fire hose stream. Despite this extremely severe treatment, concrete masonry walls have come through the tests with practically no spalling. After the panel has cooled, but within 72 hr. after it is pulled away from the furnace, it is subjected to a double-load test—that is, the load on the wall, which up to this time was 80 p.s.i., is increased to 160 p.s.i.

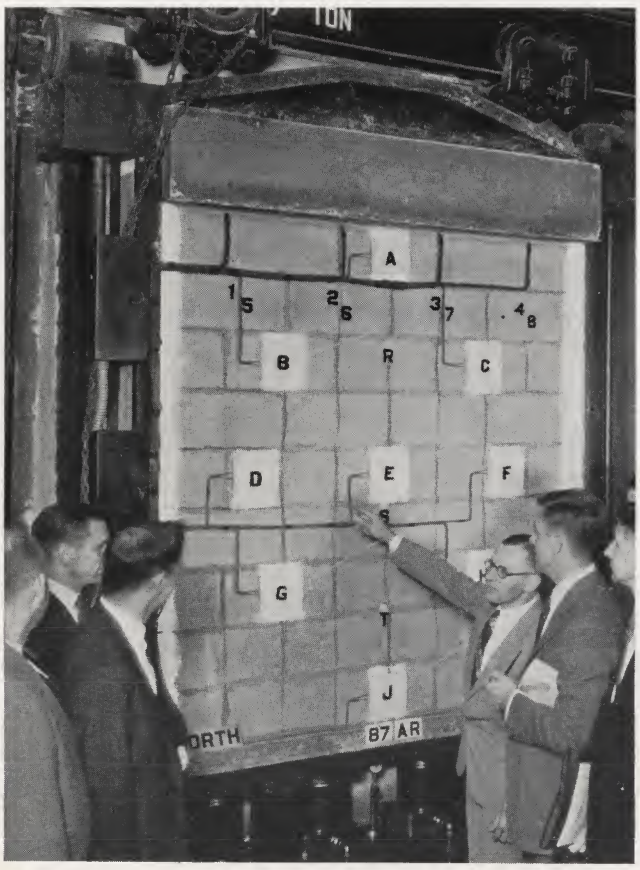


Fig. 9. Concrete masonry wall in position for fire testing at Portland Cement Association Laboratory.

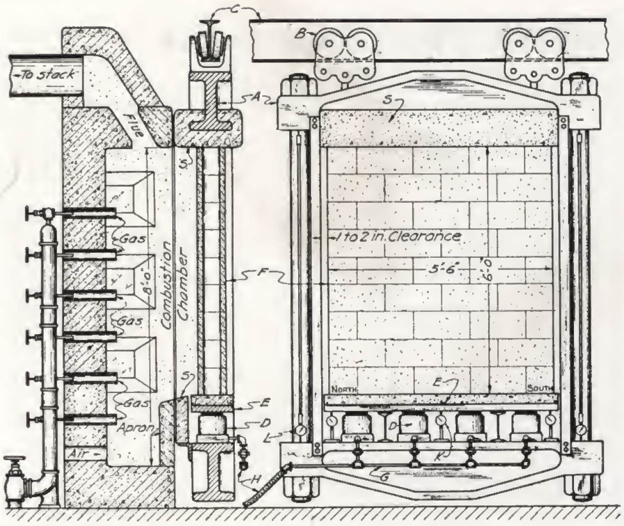


Fig. 11. General arrangement of fire test furnace and movable test frame, Research Laboratory, Portland Cement Association. Principal apparatus consists of vertical gas-fired furnace, movable steel test frame (A) and four hydraulic jacks (D)—total capacity 400,000 lb.—for loading test wall (F).

Outstanding Test Data

Further data on the strength of concrete masonry walls after fire exposure were reported by C. A. Menzel* at the 1931 meeting of the American Society for Testing Materials and at the 1932 meeting of the American Concrete Institute. His reports described tests in the Research Laboratory, Portland Cement Association, in which duplicate panels were built, both of which were tested for compressive strength, one being first subjected to the standard fire exposure test.

The two curves in Fig. 10 show the relation of wall strength to unit strength before and after fire exposure. The upper curve is for walls tested before fire and shows wall strength to be 55 per cent of the strength of the units. The strength values represented by the circles are for walls after 3 to 3½ hr. of fire exposure. Wall strength averaged 28 per cent of the original strength of the units. Walls built with 1000-p.s.i. units had a strength of 280 p.s.i. Walls built with 700-p.s.i. units had a factor of safety of considerably more than 2 after severe fire exposure.

The following summary and conclusions of Mr. Menzel's A.C.I. paper, "The Strength of Concrete Masonry Walls After Fire Exposure," as published in *Rock Products* for March 12, 1932, give additional facts regarding the tests:

(1) The compressive strength of concrete masonry walls, tested both without exposure to fire and after exposure to fire, was directly proportional to the original compressive strength of the units.

(2) The strength of walls, tested without exposure to fire and constructed of units of a given design and strength, was independent of the type of aggregate, depended to some extent on the type of mortar, but depended mainly on the type of mortar joints and character of mortar bedding. After exposure to fire, the wall strength was influenced to a more marked degree by the type of aggregate than by the type of mortar, but to an even greater extent by the type of mortar joints and character of mortar bedding.

(3) Closely similar strengths were obtained from walls laid up with units of a given strength with portland cement-lime mortars ranging from 1:1:6 to 1:0.15:3. When the cement content of the mortar was reduced below that of a 1:1:6 mix, there resulted a decrease in wall strength which was approximately proportional to the decrease in the cement content of the mortar.

(4) The strength of walls plastered on either the exposed face or on both faces was appreciably higher after fire exposure than that of similar unplastered walls.

(5) No outstanding advantage was discernible in wall strength after fire exposure for one design of unit over another in tests of walls of the same thickness, laid up with units of different design but comparable as to the proportion of core area, the proportion of net area bedded, and strength (p.s.i. gross area).

(6) An outstanding feature of the investigation was the substantial load-carrying ability and safety exhibited by the walls before, during and after severe fire exposure.

Fig. 12. Concrete masonry wall after fire and hose stream test, Underwriters' Laboratories. No marked spalling or erosion occurred.

**Associate Engineer, Research Laboratory, Portland Cement Association, Chicago, Illinois.*

Concrete Masonry Is Excellent Fire Retardant

What is meant by the fire-retardant classification of a masonry wall?

It is a means used to classify materials according to the length of time they can be depended upon to resist fire. The length of time that a given material will act as a fire retardant is determined by tests. (See Section 8 for description of the procedure followed in making tests at Underwriters' Laboratories, Inc.)

A material that successfully withstands the fire endurance test for 2 to 3 hr. is given a 2-hr. rating (D-2); a material that successfully undergoes the test for 3 to 5 hr. is classified as a 3-hr. fire retardant (C-3); and a material that stands the test from 5 to 8 hr. is classified as a 5-hr. retardant (B-5). There also are other ratings as determined by tests.

A wall is considered to have failed as a fire retardant when there is passage of flame through the wall or there is a rise in temperature of 250 deg. F. above room temperature on the unexposed face when tested in a furnace in accordance with A.S.T.M. specifications.

What is the practical value of Underwriters' Laboratories' approval of concrete masonry construction?

When a material or product has successfully withstood the fire tests it is given a classification as a fire retardant and becomes eligible for certification. A high-class modern building is a composite of listed, labeled, and certified materials and products. Many of these—sprinkler systems, fire doors, wire glass windows, window frames, elevator equipment, heating and cooling appliances and electrical installations—bear the certification of Underwriters' Laboratories. This certification service is recognized by architects and builders as assurance, on the basis of impartial tests, that the material or product may be depended on to give satisfactory service under extreme conditions. The data obtained through tests are supplied to insurance underwriters and serve as the basis for establishing fire insurance rates.

Is concrete masonry the only kind of hollow masonry that has been tested and given a fire-retardant classification?

For a number of years concrete masonry was the only hollow masonry material that was eligible to the Inspection Service of Underwriters' Laboratories, but recently plans were worked out whereby certain types of clay tile are now eligible to receive

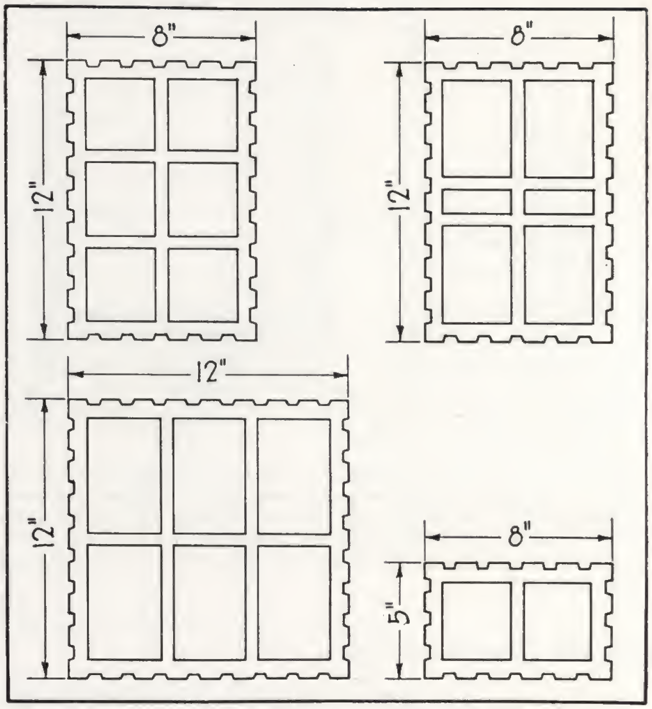
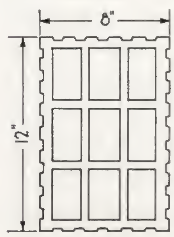
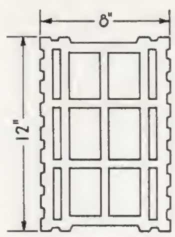
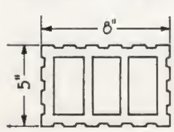


Fig. 13. Typical designs of clay tile which are not given fire-retardant ratings by Underwriters' Laboratories.

TABLE 9—Underwriters' Laboratories' Standard
(Structural Clay Tile)

Typical Standard Designs of Tile

Design	Length	Methods of Laying	Classification
	12 in.	End or Side Construction	Class D-2 in 8-in. walls. Class C-3 in 3-cell single unit 12-in. walls. Class B-5 in 4-cell 2-unit 12-in. walls.
	12 in.	End Construction (End or Side Construction in 8-in. Wall only)	Class D-2 in 8-in. walls. Class B-5 in 4-cell 2-unit 12-in. walls.
	12 in.	Side Construction	Class D-2 in 8-in. walls. Class B-5 in 4-cell 2-unit 12-in. walls.

this service. Table 9 shows three of the types of clay tile that are eligible. The Inspection Service on clay tile applies only to units which have at least three cells through the wall. Other limitations are that the tile units shall be not more than 12 in. long; the face shell thickness must be at least ⅝ in. for exterior shells and ½ in. for interior shells, except in the case of double-shell tile, when each shell must be at least ½ in. thick.

Several types of clay tile are not eligible for listing by Underwriters' Laboratories as 2-hr. fire retardants. Those shown in Fig. 13 are ineligible because they have only two cells or can be laid with only two cells through the thickness of the wall.

What types of concrete masonry units have been tested at Underwriters' Laboratories and are eligible for the Inspection and Certification Service?

The standard requirements for concrete masonry units eligible for the Inspection Service are shown in Table 10. Practically all concrete masonry units now manufactured in the United States are eligible. Certification is based on the kind of aggregate and the design of the unit. Only types of units that have successfully passed the standard fire test are eligible.

Concrete masonry units meeting standard requirements are classified as 2, 3 and 4-hr. fire retardants in 8-in. walls as compared with a maximum of 2-hr. for clay tile. For details of Underwriters' Laboratories' requirements for concrete masonry units see page 60.

TABLE 10—Underwriters' Laboratories' Standard for Concrete Masonry Units

Type of Unit and Aggregate	Average Min. Face Shell and Internal Web Thicknesses (inches)								
	Class D-2 Retardants			Class C-3 Retardants			Class B-4 Retardants		
	Face Shell		Web	Face Shell		Web	Face Shell		Web
	Avg.	Min.	Min.	Avg.	Min.	Min.	Avg.	Min.	Min.
HOLLOW UNITS All Aggregates except Haydite, Superock, Waylite	1⅜	1¼	1	1¾	1½	1			
HOLLOW UNITS Haydite Aggregate	1¼	1⅛	1	1½	1⅜	1			
HOLLOW UNITS Superock and Waylite Aggregates	1¼	1⅛	1				1½	1⅜	1
SOLID UNITS* All Aggregates except Siliceous							2¼	2⅛	1½

*Volume of core space not to exceed 25 per cent.

Do building codes include fire-retardant classification provisions?

Several codes already have fire-retardant classification provisions and they doubtless will become as common as strength and absorption requirements. Anticipating that such provisions soon will be required, the Building Code Committee of the U. S. Department of Commerce has drafted an outline to serve as a guide in rewriting codes to include fire-retardant classifications. This is given in a bulletin, "*Recommended Minimum Requirements for Fire Resistance in Buildings.*"

Important Facts About the Fire-Retardant Value of Masonry Walls

Concrete masonry units meeting standard requirements are classified as 2, 3 and 4-hr. fire retardant for 8-in. walls as compared with a maximum of 2-hr. for clay tile.

The greater percentage of concrete masonry units as now manufactured in the United States is eligible for Underwriters' Inspection Service.

Underwriters' Laboratories' standards should be followed as a guide in specifying fire-retardant classifications for masonry walls in building codes or in individual specifications.

Heat Transmission of Concrete Masonry Walls

THE question of heat transmission of walls used in office buildings and residences is assuming increasing importance as the use of higher priced fuels and the installation of air conditioning equipment increases.

From what standpoint is wall insulation important?

A certain amount of wall insulation is important, not only from the standpoint of reducing fuel bills in winter and providing cooler rooms in summer, but also from the standpoint of preventing condensation or the appearance of moisture during cold weather on the interior walls in buildings using humidifying equipment.

The heat insulation value of various types of concrete masonry walls is shown in Table 11. The values given are based on data obtained in a research program sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the Portland Cement Association and the University of Minnesota. The report was published in the January 1936 issue of *Heating, Piping and Air Conditioning* under the title, "Thermal Properties of Concrete Construction," by F. B. Rowley, A. B. Algren and Clifford Carlson of the Engineering Experiment Station staff of the University of Minnesota.

How does the heat loss in concrete masonry walls compare with that of walls constructed of other materials?

For comparative purposes in using this table, the heat loss coefficients of other types of construction have been taken from the 1939 *Guide* of the American Society of Heating and Ventilating Engineers. These engineers measure heat loss in terms of British thermal units (B.t.u.)—units used to measure heat in much the same manner that we use pounds to measure weight. Standard wood frame construction with ¾-in. plaster on metal lath has a heat loss of .26 B.t.u. per sq. ft. per hr. This figure, .26 B.t.u. loss, is considered by heating and ventilating engineers as not excessive as far as efficiency is concerned. In fact, it is quite generally accepted as the basing point on which efficiency or inefficiency of heat losses may be measured.

Similar wood frame construction with 4-in. brick veneer in place of siding and ¾-in. plaster on metal lath interior has a heat loss of .28 B.t.u. per hr. An 8-in. solid brick wall with furred metal lath and ¾-in. plaster has a heat loss of .32 B.t.u. per hr.

Table 11 indicates the results secured in the co-operative tests at the University of Minnesota for various types of concrete masonry units. A study of this table and the comparative values given will bring out an important point not generally recognized: that is, the very small difference in the heat loss between frame and concrete masonry walls, provided they have the same interior treatment.

What is a simple method of increasing the insulating value of concrete masonry walls?

One of the outstanding facts brought out in the investigation conducted at the University of Minnesota was that filling the cores of a standard 3-oval core 8x8x16-in. unit with regranulated cork, rock wool, or similar granular or loose fill material with equivalent insulation values would reduce the heat losses through the plain concrete masonry wall substantially 50 per cent. This method of providing additional insulation in concrete masonry walls will prove economical and effective. The test results show that a cinder or Haydite concrete masonry wall with filled cores and two coats of portland cement paint on the exterior, without interior plaster, reduces the heat losses to 20 per cent less than standard frame construction.

Is window insulation as important as wall insulation?

While a certain amount of wall insulation is desirable in all types of modern buildings, in general, the importance of additional wall insulation in reducing fuel costs has been over-emphasized. The increasing use of larger window areas in buildings of all types is placing greater emphasis on window insulation than on wall insulation. If the window area of a building is increased only 3 per cent, the relative importance of the wall insulation in reducing fuel costs is reduced 6 per cent. This is true because ordinarily a greater amount of heat is lost through the windows than through the walls of any building.

In what other ways do heat losses occur?

For example, in determining the heating costs of a given building, factors other than wall insulation must be given consideration because, ordinarily, the major heat losses do not occur through the walls. A 27x34-ft. uninsulated 1½-story house built with light-weight concrete masonry exterior walls, furred metal lath and plastered interior finish, with 25 per cent of the wall area in windows and doors, will have approximately the following

TABLE 11—Heat Transmission of Various Types of Concrete Masonry Walls

Based on data obtained in cooperative research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the Portland Cement Association and the University of Minnesota. The report was published in the January 1936 issue of *Heating, Piping and Air Conditioning* under the title, "Thermal Properties of Concrete Construction," by F. B. Rowley, A. B. Algren and Clifford Carlson of the Engineering Experiment Station staff.

Coefficient of Transmission *U* of Concrete Masonry Walls, Wind Velocity 15 Mi. Per Hr.										
Basic Wall Construction (See Note)	Cores of Units Not Filled					Granular or Loose Fill in Cores**				
	Interior Finish					Interior Finish				
	Plain* Wall, No Plaster	½-in. Plaster on				Plain Wall, No Plaster	½-in. Plaster on			
		Wall Direct	Furred				Wall Direct	Furred		
			Metal Lath	Rigid Insulation				Metal Lath	Rigid Insulation	
				½-in.	1-in.				½-in.	1-in.
8-in. Concrete Masonry Walls. Aggregate:										
Cinder	.40	.37	.27	.20	.16	.20	.20	.17	.15	.11
Haydite	.36	.34	.25	.19	.15	.18	.18	.15	.13	.11
Sand or Limestone	.53	.49	.32	.24	.17	.38	.36	.26	.20	.16
12-in. Concrete Masonry Walls. Aggregate:										
Cinder	.37	.35	.25	.19	.15					
Haydite	.34	.32	.24	.19	.14					
Sand or Limestone	.48	.45	.31	.23	.17					
12-in. Walls (4-in. brick, 8-in. C/M back-up) Aggregate:										
Cinder	.34	.32	.24	.19	.15	.18	.18	.15	.13	.11
Haydite	.31	.30	.23	.18	.14	.17	.16	.14	.12	.10
Sand or Limestone	.42	.39	.28	.21	.16	.27	.25	.20	.16	.13
9-in. Double; 4-in. C/M Walls with 1-in. air space. Aggregate:						Granular or Loose Fill in 1-in. Air Space				
Cinder	.28	.27	.21	.16	.13	.18	.17	.14	.12	.11
Haydite	.25	.24	.19	.15	.12	.15	.15	.13	.11	.10
Sand or Limestone	.40	.37	.27	.20	.16	.25	.24	.19	.15	.12
4-in. Wall C/M partition unit. Aggregate:										
Cinder	.56	.52	.34	.23	.17					
Haydite	.51	.47	.32	.22	.17					
Sand or Limestone	.70	.64	.39	.25	.18					

NOTE: Concrete masonry walls built with units made of standard light-weight aggregates have heat transmission coefficients comparable to the walls made of cinder and Haydite units.

The values underlined in the table indicate actual test results. Other values calculated using these values as a base. All values are based on units with one air cell in the direction of heat flow.

*_Two coats portland cement paint reduce the value of_ U _on plain concrete masonry walls .02 to .03 B.t.u._

**_Granular or loose fill placed in the cores of the 8-in. units or in the 1-in. air space of double wall construction consisting of regranulated cork, rock wool, expanded micaceous shale or similar materials having equivalent heat loss coefficient._

heat losses through the various parts of the building:

35 per cent through windows and doors,
30 per cent through the roof,
20 per cent through the walls,
15 per cent around wall openings.

If all the heat losses through the walls were eliminated, the maximum saving in fuel would be only 20 per cent, other conditions in the building remaining the same.

Heating engineers generally agree that little is to be gained by reducing the heat loss beyond .15 B.t.u. In other words, the cost of insulation to provide a wall with a heat loss below this point may be out of proportion to the fuel saved. To secure this condition in 8-in. concrete masonry walls or exterior frame walls requires the addition of 1 in. of rigid insulation or its equivalent, as will be seen in Table 11. This amount of additional insulation in the above typical house would reduce the actual fuel bill only 8 per cent.

Providing storm windows and doors for this house would reduce the fuel cost about 18 per cent and providing insulation in the roof equivalent to 3½ in. of rock wool or similar material would reduce the heating cost 15 per cent.

Sound-Absorbing Value of Concrete Masonry*

CONTROL of sound is now regarded as a necessity in practically all types of buildings, especially in those used for public gatherings where it is desirable for the human voice to be heard clearly and distinctly and in homes and offices where quiet contributes to the comfort and efficiency of the occupants. Because of this trend to control sound, the Portland Cement Association, in cooperation with the University of Illinois, has investigated the sound-absorbing values of concrete of different compositions and physical properties.

What types of concrete have greatest sound-absorbing values?

The results show that porous materials absorb sound, but dense materials with small porosity are generally not efficient in absorbing sound. Haydite and cinder concrete masonry units have higher sound-absorbing values than units made of sand and gravel aggregates. However, despite their density the sand and gravel specimens tested were found to be more sound-absorbent than the usual hard plasters and cements, and can be used advantageously in buildings to reduce noise.

How are tests made?

One method used the Sabine reverberation method in which the time that elapses when various standard sounds die out in a specially prepared room, both with and without the sound-absorbing samples, is measured. Calculations based on these periods give coefficients of absorption that can be used to determine the area or amount of sound-absorbent surface that will be needed to control the sound in any room. Electrical apparatus is used to generate the sound and to measure the length of time it takes to die out. This length of time is also determined with the ear, using a stop watch, thus giving an acceptable comparison with the instrumental results.

The advantage of porosity in materials in absorbing sound is shown by the portland cement specimens under investigation. Table 12 gives numerical data for the sound absorptivity, and Table 13 details of aggregates, mixes and the physical properties of concrete for the specimens tested.

Condensed from article, "Sound-Absorbing Value of Portland Cement Concrete," by F. R. Watson, Professor of Experimental Physics, and Keron C. Morrical, Research Assistant, University of Illinois, published in American Concrete Institute, 1936 Proceedings, *pg. 659.*

Fig. 14. The reverberation room, University of Illinois, in which large panels of concrete masonry units were assembled and tested to determine their sound-absorbing values.

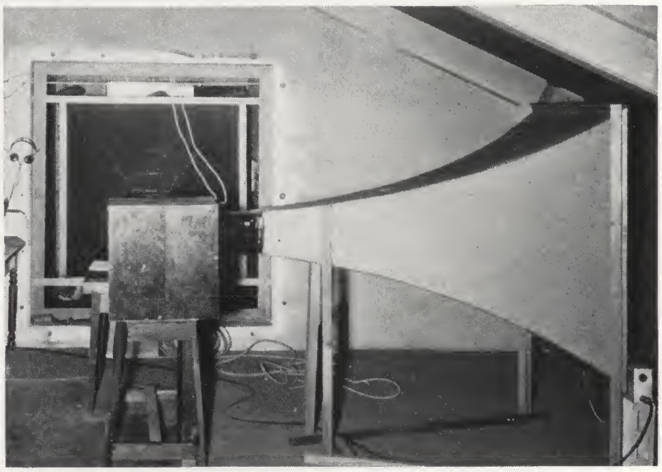


Fig. 15. Instruments used to record sound-absorbing values of various types of concrete masonry walls at University of Illinois.

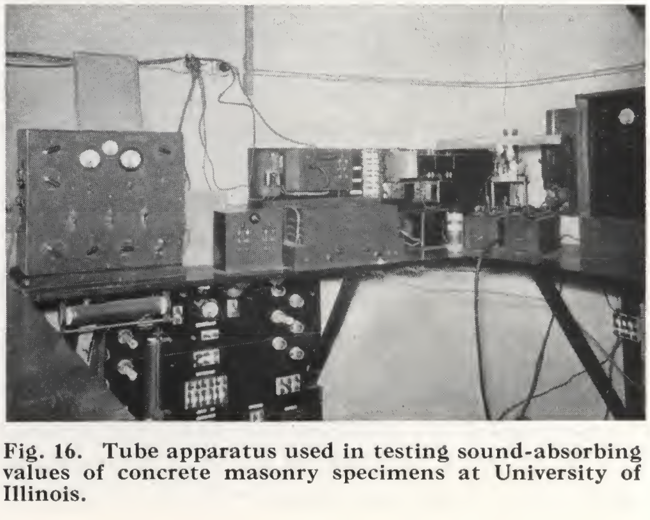


Fig. 16. Tube apparatus used in testing sound-absorbing values of concrete masonry specimens at University of Illinois.

What effect does painting have on acoustical materials?

If the pores of an acoustical material are closed by paint, some of the absorbing value is taken away. Spray painting will close fewer pores than brush painting. Oil paints reduce sound absorptivity more than water paint. The effect of spray painting with cement and water paint is shown in Table 12, where the average absorptivity was reduced 10 per cent or more.

When is an acoustical material considered useful?

The absorption of sound in a room takes place almost entirely at the surfaces where the sound is reflected. The usual interior surfaces—hard plaster, wood and glass—absorb only about 3 per cent (absorbing coefficient 0.03) of this incident sound. Any material that absorbs 15 per cent or more is regarded as useful in buildings. Inspection of the absorption coefficients in Table 12 shows that the Haydite and cinder concretes have average coefficients approximating 0.50, meaning that they absorb 50 per cent of the incident sound at each reflection, and that they will be efficient absorbers of sound in rooms. Materials with smaller coefficients, but more than 0.15, are also useful; a building completely lined with such materials would be noticeably quiet compared with present modern buildings where the surfaces absorb about 3 per cent.

How do you determine the efficiency of various acoustical materials?

As an example, consider the quieting effect of using a sound-absorbing tile of coefficient 0.18 for the walls and ceiling of a room instead of the inefficient hard plaster of coefficient 0.03. Suppose the room is an office 15 ft. square by 10 ft. high, for which the volume is 2250 cu. ft., and that it has a linoleum floor covering. The calculations of the acoustic conditions are as follows:

Hard plaster on walls and
ceiling, 825 sq. ft. at 0.03 . . 24.75 units of absorption
Linoleum on floor, 225 sq. ft.
at 0.03 . . . . 6.75 units of absorption
31.50 units of absorption

The time t taken for an average sound to die out in the room is calculated from the equation: $t = 0.05 \times$ volume $\div$ absorption, or, $t = 0.05 \times 2250 \div 31.50 = 3.57$ seconds.

With the absorbing tile used instead of the hard plaster, the calculations become:

Fig. 17. Texture of concrete masonry specimen having a high sound-absorbing coefficient.

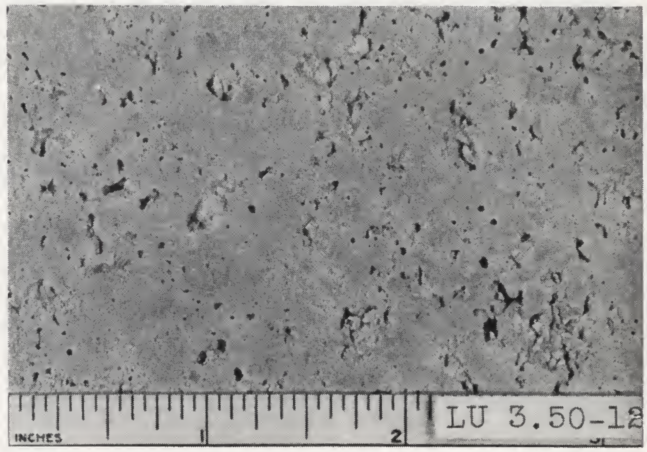


Fig. 18. Texture of concrete masonry specimen having a low sound-absorbing coefficient.

Absorbing tile, 825 sq. ft.
at 0.18 . . . . 148.5 units of absorption
Linoleum, 225 sq. ft.
at 0.03 . . . . 6.75 units of absorption
155.25 units of absorption

$t = 0.05 \times 2250 \div 155.25 = 0.72$ seconds.

These calculations show that the office with hard plaster walls and ceiling would have disturbing sounds that would not disappear for 3.57 seconds, while with the sound-absorbing tile, such as the painted sand and gravel units (S-2-S in Table 12), the sound would die out in 0.72 seconds, and the room would have the quiet conditions needed to allow the occupants to do efficient work. For larger rooms and auditoriums, it is desirable to use quieting materials with larger coefficients, such as Haydite or cinder concrete units.

The compositions listed in Table 12 consisted of standard 4x8x16-in., 3-core concrete masonry

partition units, made in a power tamper, stripper machine in a commercial plant. The units were laid with ⅜-in. mortar joints so as to give an area of 82.5 sq. ft. The cinder concrete and the sand and gravel concrete specimens were tested first plain, then again after spray painting with a portland cement and water paint. Each coefficient recorded is the average of some 150 separate measurements of the time of decay of sound, giving a total of approximately 10,000 measurements for all the coefficients in Table 12. Five standard, pure sounds were used of frequencies 250, 500, 1000, 2000 and 4000 cycles per second, thus giving the coefficients over a wide range. The average of these five values gives a more suitable basis for comparing the different compositions than the values for any one frequency. Inspection of the average values shows that painting reduces the absorbing efficiency, depending on how much the pores are closed to the sound. The cinder and Haydite concretes show the greatest sound-absorbing values. All the compositions in Table 12 can be used beneficially for absorbing sound in buildings.

TABLE 12—Absorption Coefficients Using Large Areas of Materials in the Reverberation Room

(Specimens built of 4x8x16-in. Concrete Partition Tile)

Material	Frequency of Sound 250	500	1000	2000	4000	Average Coefficient
CINDER AGGREGATE CONCRETE						
C-1-S (Unpainted)	0.47	0.51	0.61	0.61	0.55	0.55
C-1-S (Painted)	0.44	0.44	0.52	0.55	0.52	0.49
C-2-S (Unpainted)	0.58	0.44	0.36	0.58	0.58	0.51
C-2-S (Painted)	0.58	0.39	0.33	0.45	0.47	0.44
SAND AND GRAVEL AGGREGATE CONCRETE						
S-1-S (Unpainted)	0.28	0.35	0.50	0.44	0.36	0.37
S-1-S (Painted)	0.25	0.29	0.28	0.24	0.27	0.27
S-2-S (Unpainted)	0.26	0.35	0.35	0.21	0.16	0.27
S-2-S (Painted)	0.20	0.23	0.18	0.13	0.16	0.18
LIMESTONE AGGREGATE CONCRETE						
L-1-S	0.21	0.26	0.21	0.19	0.20	0.21
L-2-S	0.23	0.22	0.23	0.23	0.15	0.21
HAYDITE AGGREGATE CONCRETE						
H-1-S	0.58	0.56	0.33	0.51	0.50	0.50
H-2-S	0.42	0.70	0.33	0.54	0.51	0.50

NOTE: Later tests made on walls built with concrete masonry units made of expanded slag aggregates give sound-absorption values comparable to values shown for cinder and Haydite units.

TABLE 13—Details of Aggregates, Mixes and Physical Properties of Concrete in Units for Sound-Absorption Tests (4x8x16-in. Hollow Concrete Tile)

Specimen Identification Number	AGGREGATE Type	Fineness Modulus	Dry Rodded Weight Lb. per cu. ft.	CONCRETE Cu. Ft. Dry Rodded Aggregate Used Per Sack Cement	Weight of Dry Concrete Lb. per cu. ft.	Compressive Strength Lb. per sq. in. Gross Area	Water Absorption: Per Cent of Dry Weight of Concrete	Water Absorption: Per Cent by Volume of Concrete
C-1-S	Cinders	3.50	67.0	8	83.2	460	16.2	21.5
C-2-S	Cinders	4.50	62.8	8	82.2	560	14.1	18.6
H-1-S	Haydite	3.50	54.0	9	67.5	880	20.5	22.2
H-2-S	Haydite	4.50	49.6	9	59.5	610	15.3	14.5
S-1-S	Sand and Gravel	3.50	113.5	10	117.4	980	9.1	17.1
S-2-S	Sand and Gravel	4.50	117.6	10	127.5	1470	5.9	12.1
L-1-S	Limestone	3.50	111.0	10	123.1	1180	8.6	16.9
L-2-S	Limestone	4.50	104.75	10	123.0	1280	7.7	15.2

IMPORTANT FACTS ABOUT CONCRETE MASONRY AS AN ACOUSTICAL MATERIAL

Concrete masonry units made of porous aggregates such as Haydite, cinders and expanded slag are efficient from a sound-absorbing standpoint.

Sand and gravel units have greater sound-absorbing efficiency than the usual hard plasters and other hard finishes.

Painting concrete masonry surfaces will reduce sound-absorbing efficiency in proportion to the number of pores closed.

Fig. 19. Castilla Cafe, Kansas City, Mo. Concrete masonry units made of light-weight aggregate having sound-absorbing properties assure diners of a quiet, homelike atmosphere.

Sound Transmission Through Concrete Masonry Walls

WHILE the transmission of sound and absorption of sound are two entirely different functions of a wall of a modern building, they are usually considered together.

Is there a direct relationship between weight of walls and their sound-reduction value?

The ability of concrete masonry walls to reduce sound transmission is brought out in Paul E. Sabine's book, *Acoustics and Architecture*, published by the McGraw-Hill Book Co., Inc. In this book the author points out that generally the sound transmission of continuous masonry partition walls as measured by sound reduction varies with the weight of the wall. Actual test values obtained for various types and weights of continuous masonry walls indicate that there is a direct relation between the sound reduction and the weight of the wall.

Is the sound-reduction value of concrete masonry greater than that of other masonry materials?

Tests reported in this book on plastered concrete masonry unit walls made with cinder, Haydite or expanded slag aggregate also show a direct relation between sound reduction and the weight of the wall when plotted in a similar manner. The sound reduction obtained, however, was considerably greater than for tile, plaster and brick walls of equal weight. The three concrete masonry walls reported were similar in that the aggregate used is what is commonly known as light-weight and has a coarse angular structure.

The plotted curves indicate that plastered light-weight concrete masonry walls weighing 25, 35, 45 and 55 p.s.f.* would be as effective in reducing sound transmission from one room to another as continuous masonry, plaster, clay tile or clay brick walls weighing 40, 53, 65 and 77 p.s.f., respectively. The above weights of light-weight concrete masonry walls (25, 35, 45 and 55 p.s.f.) would result in the average reduction of sound transmitted of 44, 47.5, 50.5 and 53 decibels, respectively.

**p.s.f.—pounds per square foot.*

FACTS TO REMEMBER ABOUT SOUND TRANSMISSION

There is a direct relationship between the amount of sound reduction and weight of wall.

When light-weight aggregates are used, there is a greater sound reduction in walls of concrete masonry units in proportion to their weight than in those of other masonry materials.

Sound-reduction values of concrete masonry walls are greater in respect to the weight of the wall than those of other masonry walls.

Concrete Masonry Is Exceptionally Economical

ITS economy, as compared to other types of masonry construction, is one of the principal reasons for the rapid increase in the use of concrete masonry. Architects, builders, owners and others ordinarily scrutinize costs even more closely now than in the past, which means that concrete masonry, because of its definite economies, is occupying an increasingly important position in the building construction field.

Concrete masonry is economical to use because the units are relatively large, true to size and shape, and provide good mortar bedding—factors which insure rapid construction with efficient use of the mason's and helper's time.

The fewer joints in concrete masonry result in considerable saving in mortar as compared to masonry construction built with brick-size units. The advantages of more wall laid per mason-hour and the saving in mortar give concrete masonry a decided cost advantage in most sections of the country. The actual saving in any particular locality, however, must be calculated on the basis of local prices of materials and local wage scales.

How to Use Tables

Tables 14, 15 and 16 include information which will help the estimator determine the number of units required to build 100 sq. ft. of wall for three types of masonry construction—concrete masonry, clay tile, and brick. The tables also give quantities of mortar and number of labor-hours required for each of the three types. Data in Table 14 have been collected by the National Concrete Masonry Association and are conservative. Table 15 is based on data contained in *Brick—How to Build and Estimate*, published by the Common Brick Manufacturers' Association of America. Table 16 is in close agreement with the estimating data for clay tile as given in Walker's *Building Estimators'*

TABLE 14—Concrete Masonry

Weights and Quantities of Materials and Time Required to Build 100 Sq. Ft. of Concrete Masonry Wall

3½-in. Course Height—12-in. Length

	Heavy Aggregate*			Light Aggregate**		
Wall Thickness	4-in.	6-in.	8-in.	4-in.	6-in.	8-in.
Weight of Finished Wall (lb.)	3050	4300	5550	2000-2200	2600-3000	3300-3800
Units (number)	300	300	300	300	300	300
Mortar (cu. ft.)	5	5½	6	5	5½	6
Mason (hr.)	3	3½	4	2¾	3¼	3½
Labor (hr.)	2½	3¼	3¾	2¼	3	3¼

5-in. Course Height—12-in. Length

	Heavy Aggregate*			Light Aggregate**		
Wall Thickness	4-in.	6-in.	8-in.	4-in.	6-in.	8-in.
Weight of Finished Wall (lb.)	2700	3800	4900	1700-1950	2200-2500	2900-3300
Units (number)	220	220	220	220	220	220
Mortar (cu. ft.)	5	4	5	5	4	5
Mason (hr.)	3¼	3½	4	3	3¼	3½
Labor (hr.)	2¾	3¼	3¾	2½	3	3¼

8-in. Course Height—16-in. Length

	Heavy Aggregate*				Light Aggregate**			
Wall Thickness	4-in.	6-in.	8-in.	12-in.	4-in.	6-in.	8-in.	12-in.
Weight Finished Wall (lb.)	3450	5000	5850	9125	2000-2350	2900-3300	3300-3850	5400-6300
Units (number)	110	110	110	110	110	110	110	110
Mortar (cu. ft.)	3¼	3¼	3¼	3¼	3¼	3¼	3¼	3¼
Mason (hr.)	3	3½	3¾	4½	2½	3	3¼	4
Labor (hr.)	2½	3	3½	4	2	2½	3	3½

**Heavy aggregate includes sand, gravel and limestone.*

***Light aggregate includes cinders, burned shale and water-cooled slag.*

Mortar quantities are based on ⅜-in. joints and mortar used on the ends and bed planes of the face shells. Twenty-five per cent wastage included. Figures for time required to build given for straight wall work. For back-up or for walls cut up with numerous openings or pilasters, mason and labor hours should be increased 10 to 20 per cent.

TABLE 15—Brick

Weights and Quantities of Materials and Time Required to Build 100 Sq. Ft. of Brick Wall

Wall Thickness	4-in.	8-in.	12-in.	16-in.
Weight Finished Wall (lb.)	3678	7881	11541	15500
Brick (number)	617	1233	1849	2465
Mortar (cu. ft.)	8	20	32	44
Mason (hr.)—Common Bond	6½	9	14	15
Mason (hr.)—Other Bonds	6½	11	16	18
Labor (hr.)	5	10	15	19

Joints ½ in. thick assumed.

Handbook. In Tables 14, 15 and 16, labor-hours required include time incident to mixing mortar, tending mason and moving scaffolding.

Example—Suppose it is desired to determine the relative costs of concrete masonry (8 x 8 x 16-in. units), clay tile (8 x 12 x 12-in. units) and clay brick for the construction of a building requiring 2000 sq. ft. of 8-in. wall. From Tables 14, 15 and 16, quantities of materials and number of labor-hours for building 100 sq. ft. of wall are taken. These figures are multiplied by 20 to get the requirements for 2000 sq. ft. of wall. This information may be tabulated as follows:

Type of Construction	Size of Units	No. of Units	Mortar (cu. ft.)	Labor-Hrs. Mason	Labor-Hrs. Labor
Concrete Masonry	8x8x16-in.	2200	65.0	65	60
Clay Tile	8x12x12-in.	1860	98.0	106	94
Brick	Standard	24660	400.0	180	200

Obtaining Relative Costs

By substituting local prices for materials and local mason and labor costs, the relative costs of the three types of masonry in any given locality can be determined. In Table 17, the relative costs of 2000 sq. ft. of 8-in. wall have been worked out by substituting representative values for materials and mason and labor costs.

It is suggested that, for local use, a number of forms similar to that at bottom of page 30 be ruled up and filled out, using local prices of materials and local mason and labor costs, in order to compare prices of concrete masonry, laid in the wall, with the cost of competitive types of masonry.

Saving in Plaster or Stucco

Where walls are to be plastered or covered with portland cement stucco, concrete masonry frequently affords additional economies, since the regular size units result in walls with true plane surfaces which require a minimum amount of

TABLE 16—Clay Tile

Weights and Quantities of Material and Time Required to Build 100 Sq. Ft. of Hollow Clay Tile Wall

End Construction—Cells Vertical—Course Height and Unit Length, 12 in.

Wall Thickness	4-in.	6-in.	8-in.	10-in.	12-in.
Weight Finished Wall (lb.)	2130	3190	3880	4580	5636
Tile (number)	93	93	93	93	93
Mortar (cu. ft.)	2.5	3.6	4.9	6.0	7.3
Mason (hr.)	3.3	4.3	5.3	6.0	7.0
Labor (hr.)	2.7	3.7	4.7	5.5	6.5

Side Construction—Cells Horizontal—Length, 12 in.

Size of Unit: (in.)	3¾x5x12	8x5x12 ("L")	8x6¼x12 ("T")	8x10¼x12 ("H")
Wall Thickness	4-in.	8-in.	8-in.	8-in.
Weight Finished Wall (lb.)	2340	4250	3540	3950
Tile (number)	210	210	171	105
Mortar (cu. ft.)	4.5	9	8	5.25
Mason (hr.)	4.5	5.5	5.0	4.5
Labor (hr.)	4.0	5.0	4.5	4.0

End construction generally applies to load-bearing straight walls; side construction to back-up. Mason and labor hours should be increased for short walls or walls cut up with numerous openings or pilasters. Joints ½ in. thick and 25 per cent wastage of mortar assumed.

TABLE 17—Relative Costs—2000 sq. ft. of 8-in. Wall

	Concrete Masonry 8x8x16-in. Units			Clay Tile 8x12x12-in. Units			Brick		
	Quantity	Unit Cost	Total Cost	Quantity	Unit Cost	Total Cost	Quantity	Unit Cost	Total Cost
Masonry Units	2200	$0.16	$352.00	1860	$0.16	$297.60	24,660	$0.013	$320.58
Mortar (cu. ft.)	65	0.30	19.50	98	0.30	29.40	400	0.30	120.00
Mason-Hours	65	1.70	110.50	106	1.70	180.20	180	1.70	306.00
Labor-Hours	60	1.00	60.00	94	1.00	94.00	220	1.00	220.00
Total Cost			$542.00			$601.20			$966.58

Saving—Concrete masonry over clay tile......$59.20   Saving—Concrete masonry over brick..........$424.58

mortar for satisfactory coverage. There is no loss of material in filling hollows which result when irregular sized units are used. Concrete masonry also provides a surface to which plaster or portland cement stucco adheres readily, a factor of considerable importance in obtaining rapid application. Some contractors regularly quote special reduced prices when plaster or portland cement stucco is to be applied on a concrete masonry wall.

TABLE 18—Yield and Quantities of Materials for Masonry Mortars

Type	Mixed by Volume	Mortar Produced Per One-Sack Batch cu. ft.	Material Required to Produce 100 Cu. Ft. of Mortar: Cement cu. ft.	Lime cu. ft.	Sand Damp Loose cu. ft.
Cement	1:3	3.2	31.2	—	94
Cement + 10 per cent Lime by weight	1:3	3.5	28.6	6.7	86
Cement—Lime	1:1:6	6.2	16.1	16.1	97

RELATIVE COSTS
(Fill in costs for your own locality)

	Concrete Masonry 8x8x16-in. Units			Clay Tile 8x12x12-in. Units			Brick		
	Quantity	Unit Cost	Total Cost	Quantity	Unit Cost	Total Cost	Quantity	Unit Cost	Total Cost
Masonry Units	2200	....	....	1860	....	....	24,660	....	....
Mortar (cu. ft.)	65	....	....	98	....	....	400	....	....
Mason-Hours	65	....	....	106	....	....	180	....	....
Labor-Hours	60	....	....	94	....	....	220	....	....
Total Cost		....	....		....	....		....	....

Facts About Building Watertight Walls

ALL types of masonry walls which leak are sources of vexation to architects, builders, owners, masons, and to manufacturers of masonry units and mortars.

Leaky walls are not confined to any one type of masonry construction. Leaks have occurred and are occurring in walls built of the best materials and apparently with special care. The fact is often overlooked, however, that the percentage of those which leak is small compared with the large number of masonry walls which are watertight. Unfortunately, the occasional important building which has leaky walls usually receives considerable unfavorable attention, with the masonry units or the mortar erroneously being blamed for the leakage.

What causes leaks in masonry walls and how can leaks be prevented?

A logical explanation for the leaks in masonry walls is the haste with which our modern buildings are erected. Workmanship is frequently sacrificed for speed. Perfection in design and materials cannot make up for this sacrifice.

The prevention of leaky walls must begin with the design of the building, follow through the selection of materials and the supervision of the workmanship, and continue with the maintenance of the structure after its completion.

Flashing should be placed under all vertical joints in sills, coping and caps or other horizontal surfaces which may permit the accumulation of water on or the passage of water through them. (Flashing details are shown in Figs. 27, 28 and 29 on pages 47, 48 and 49.)

Projecting soldier courses and water tables, walls corbelled back, and recessed panels with projecting horizontal courses at the bottom are frequently used without consideration for the more severe exposure resulting therefrom. As a result water seeps through the vertical joints into the wall. Snow and ice melting on these surfaces greatly increases the possibility of water entering the wall. Flashing over horizontal surfaces may be necessary.

There is no alternative for adequate flashing. It should be provided under all coping, cornices, multiple-unit sills, and all other members which project from the face of the wall or whose top surfaces are subject to the wash of water or the accumulation of snow and ice.

Parapet walls should be flashed through just above the roof level and also under the coping. Only permanent, rust-resisting metal or bituminous, asphaltic or pitch preparations should be used for flashing.

Projections and drips on coping, caps, cornices and sills should always be provided. Overflowing gutters and leaky downspouts are a common source of trouble. Gutters and drains should be ample to carry away the heaviest rains. Metal from gutters should extend up under the roofing far enough to eliminate any possibility of water getting back of it.

Mortar Joints Important

Raked, stripped and struck joints greatly increase the chance for the development of leaks. In making these joints, there is a tendency to open up the body of the mortar and draw it away from the masonry unit, forming small ledges upon which water can collect. Cut joints also are likely to be torn and drawn away from the units. If these joints are used, adequate means of waterproofing or parging should be provided, or special attention given to the selection of materials and tooling of joints.

Weathered, concave and *V* joints afford the best protection against leaks and are recommended in preference to other types. Each of these provides an excellent surface for the shedding of water. Too, their formation requires an amount of pressure sufficient to compress the mortar and create a firm bond between the mortar and the units at the face of the wall.

Thin mortar joints are best, because it is known that such joints produce a stronger, more watertight wall. Thick joints may be desirable for architectural effects, but unless precautions are taken to make the wall surface tight, when the joints are more than ½ in. thick, watertightness may be sacrificed for appearance.

When walls leak, the tendency is to blame the materials even though it is highly improbable that masonry units or mortars intended for exterior work will permit the passage of water directly through them. In this connection, a report from the U. S. Bureau of Standards (*Technical News Bulletin* of April 1931, page 40) states:

"As a result of a study of water penetration into brick masonry conducted at the Bureau, it has been shown that when the interior walls of brick buildings become wet during a rain, it is likely that water has entered through open spaces

between brick and mortar rather than directly through these solid materials."

The foregoing statement is supported by the fact that leaks are as common in walls built of dense masonry units as in those built of more porous units.

No mortar, however good, can make up for defective design and poor workmanship. Leaky walls are not more common with one type of mortar than another. There is no assurance that leaks can be prevented simply by the use of a particular mortar. While some mortars are better adapted than others to particular jobs, the differences in the watertight properties are minor compared with design and workmanship.

Tight joints are essential to watertight masonry. Bed joints must be full and level and not furrowed. Head joints should be carefully buttered to fill the joints tightly. If all the joints in the exposed face of the wall are tightly filled, there is little possibility of leakage unless the design is faulty.

Tool finishing of the joint should be delayed until the mortar has stiffened sufficiently to hold its shape. A careful tooling at this time is frequently the final touch required to make the joints watertight.

While workmanship is the most important element, the mason cannot fairly be held wholly responsible for leaks arising from poor workmanship. The owner, architect and builder share the responsibility because they hire the mason and govern the type of workmanship desired. Most masons are capable of doing good work, but the economic necessity for getting a large number of units laid per day frequently works against painstaking craftsmanship.

Good workmanship, good materials and good design will add but a small percentage to the original cost of a structure. Any additional cost entailed in obtaining good workmanship will be measurably less than the expense of repairing leaks that are likely to result from attempts to save money by violating principles of good construction.

WHAT TO LOOK FOR WHEN WALLS LEAK

Were the masons hurried when walls were built so that unintentionally their workmanship was not of the best?

Was flashing placed under all coping, cornices, sills and other horizontal surfaces where water might collect and enter the wall?

Are gutters and downspouts properly installed?

Were suitable materials used for flashing, gutters and downspouts?

Were drips provided on all projecting surfaces?

Are bed joints well filled with mortar?

Are head joints fully filled with mortar?

Are there any ledges on mortar joints where water can collect and subsequently seep into the wall?

Have cracks developed where mortar joins the masonry units?

Are the mortar joints thin or thick? If thick, this fact may be causing leakage. Thin joints are best.

Are mortar joints of the type which are most readily watertight—that is, weathered, concave or *V* joints? These three types are best.

If raked, stripped or struck joints were used, was adequate waterproofing or parging provided? If not, such defects may be causing leakage.

Are there any cracks in the wall due to settlement or faulty design? (Building to prevent cracks is discussed in Section 15, "How to Prevent Cracks in Masonry Walls.")

How to Prevent Cracks in Masonry Walls

WHEN certain well-established fundamentals of good design and construction are followed, cracks are unlikely to develop in any type of masonry wall. A knowledge of these fundamentals is a valuable aid in determining the cause of wall cracking if it does occur.

There has been a tendency in some sections for competitive interests to make it appear that wall cracking occurs only in concrete masonry. This, of course, is untrue, as all types of masonry walls may crack when improperly designed and/or constructed.

Design and Construction Cracks

Footings and Foundations—A principal cause of design and construction cracks is uneven settlement of footings. Soft places under the footing or vibration from trucks, trains and street cars frequently cause uneven settlement and, regardless of the masonry material used, cracks may develop. Adequate footings carried down to solid bearing are necessary.

Bonding and Tying—Where masonry is used as back-up or partitions in structural frame buildings, the masonry should be securely anchored to the structural members by adequate metal ties. Where one masonry wall joins another, either of concrete masonry, cast-in-place concrete or other masonry, the two walls should be securely bonded with a masonry bond or with very substantial metal ties. This also applies to partition walls. Joining two walls together without bonding or tying, regardless of the masonry material used, will almost certainly result in the formation of cracks.

Temperature—A variation in temperature of 100 deg. F. will cause a change equal to ⅝ in. in the length of a masonry wall 100 ft. long. This change in length sets up stresses in the wall which are likely to cause cracking around openings or where walls abut or where story heights change, unless adequate provision is made for proper bonding of walls and a reinforced belt course is used, extending around the building, especially in long walls. The embedment of ¼-in. pencil rods in mortar joints has proved effective in distributing temperature stresses—see page 69, paragraph D.

Openings—Stress set up in the walls, due to uneven settlement, temperature, vibration or con-

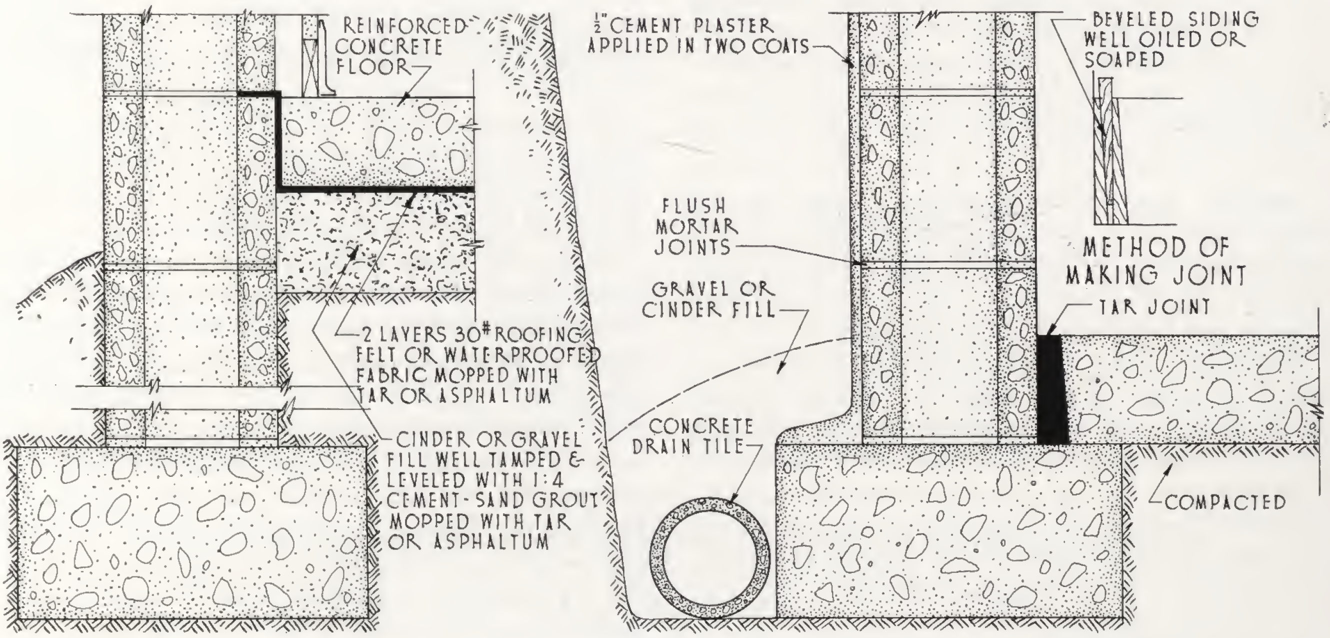


Fig. 20. Adequate foundations are essential to prevent wall cracking. Drawing on left shows the proper method of placing concrete floor on fill; drawing on right illustrates proper method of making a tight joint between foundation floor and basement wall. See Fig. 37—"Four Types of Expansion Joints for Concrete Masonry Walls."

Fig. 21. **Tight joints such as the above, that create a firm bond between mortar and units, help shed water from the face of concrete masonry walls.**

Fig. 22. **Loose, raked joints such as those shown above tend to develop leaks that are often blamed on the concrete masonry units.**

centrated loads, is more likely to produce cracks at door and window openings than anywhere else. Reinforced concrete or steel lintels, extending well into both sides of the opening, are necessary above windows and doors. Wood lintels should never be used in masonry walls.

Concentrated Loads—In long-span buildings —churches, schools, garages, etc.—loads from roof trusses or girders often cause a concentrated load on the wall sufficient to cause cracking. Such concentrated loads should be carried on pilasters or should be distributed by means of metal plates or reinforced concrete beams.

Mortar and Workmanship—Cracks in all kinds of masonry are sometimes due to the use of inferior mortar or, when the mortar is of good quality, the workmanship may be so poor that uneven and insufficient bedding results.

There are many other causes of cracking in masonry walls which might be classed under faulty design and construction, and all masonry materials from granite to adobe will suffer under improper use. In the majority of the cases, however, the reasons for cracking in any kind of masonry wall are found in the causes which are mentioned in the foregoing discussion.

Relation of Materials to Cracking

It is important to consider what effect, if any, the masonry units may have on cracking in the walls. Some place along the line from raw material to finished product, all concrete and clay masonry units go through a period of shrinkage. The clay unit shrinks when it is in the drying room and in the kiln. The concrete unit shrinks as it is being cured and while it is drying. Obtaining complete shrinkage of a masonry material, whether clay or concrete, is an important part of the manufacturing process, and the unit is not a finished product until a large part of this shrinkage has occurred.

An extensive series of tests conducted in the Research Laboratory, Portland Cement Association, show that concrete masonry units that are dry when laid will not cause wall cracking.

After the damp curing period, which follows immediately after the molding of the units and which is necessary to harden the concrete, another equally important operation is essential—that of allowing the units to become dry. Where possible, units should be stored under cover. They should be piled in narrow stock piles with cells horizontal and opposite so that the air can circulate freely through the piles. The bottom courses should be piled on boards to keep them off the damp ground. On particularly important interior work—especially in walls of large dimension—and in rainy seasons, the units should be kept dry on the job with tarpaulins or should be stored within a building.

Painting Exposed Concrete Masonry Walls

Will painting effectively waterproof concrete masonry walls?

Concrete masonry walls can be effectively sealed against water penetration if a few simple precautions are observed. These recommendations are based on rain-resistance tests on concrete masonry walls by the Development Department of the Portland Cement Association which show definitely that such walls can be made watertight with two coats of portland cement paint properly applied.

Is the manner in which the wall is laid a factor in securing a watertight job?

1. Fine or medium-textured units are recommended for building exposed concrete masonry walls. Face shells should be not less than 1¼ in. thick. Extremely coarse, open-textured concrete masonry units should not be used in exposed masonry walls. In areas frequented by heavy, driving rains, it is recommended that only concrete masonry units with dense surfaces be used.

2. Careful laying of the units by the mason is essential. Vertical joints should be well filled and shoved tight.

3. Joint treatment is no different from that usually given other types of exposed masonry walls. Tooled or weather-struck joints are best. A joint that will catch and hold water should be avoided.

4. A 1:1:6 portland cement-lime mortar is recommended (proportioned by volume).

What precautions should be taken in applying portland cement paint to concrete masonry walls?

1. Treatment of exposed walls consists in the careful application of two or more coats of portland cement paint. Where there is any doubt about obtaining a complete sealing of the surface with two coats or in sections where hard, driving rains are of frequent occurrence, a three-coat paint job is advised. *Painting exposed masonry walls should be considered primarily a waterproofing rather than a painting job.* Of course, a good paint job provides both a decorative and waterproof wall coating.

2. The best method of application is by means of a brush with short, stiff fiber bristles. Every part of the wall should be completely covered and sealed. Application with an ordinary paint brush is generally *not satisfactory,* since in most cases only the surface is covered and the paint is not forced into the depressions in the unit or mortar joint, as is necessary to make the wall thoroughly waterproof. If a spray gun is used it is important to vary the angle of the nozzle so that the spray hits every point in the wall from four or five different angles, thus completely covering it. Particular effort should be made to obtain complete coverage around window and door openings. Check carefully all points not easily accessible to the man making the application.

Portland cement base paint should be carefully applied in accordance with manufacturers' directions. Surfaces should be damp when cement paint is applied, so that even absorption is obtained. High winds, excessive heat and strong sunshine will dry cement paint quickly and render it ineffective as a waterproofing agent unless proper precautions are taken to keep it damp until properly cured. Preferably, the work should be laid out so that a minimum of direct sunshine hits the wall for the first 24 hours after the cement paint application. Work should start on the north wall in the morning and follow the shade to the east, south and west walls so that the drying action of the direct sunshine on the freshly painted walls is minimized or entirely eliminated.

Cement paint should be cured as carefully as concrete. It should be kept damp—not allowed to dry out—until it has set thoroughly. After the first coat has hardened sufficiently to prevent injury to the surface, it should again be wetted down just before applying the second coat. The second coat should also be kept damp until it has thoroughly cured and hardened—preferably for at least 48 hours after application.

A detailed information sheet on this subject may be obtained by writing the National Concrete Masonry Association for "*Suggested Specifications for Application of Portland Cement Paint*".

FACTS TO REMEMBER WHEN PAINTING CONCRETE MASONRY WALLS

Units having face shells no less than 1¼ in. thick, well laid with a 1:1:6 portland cement-lime mortar, are the first essentials of a waterproof wall.

Painting exposed masonry walls should be considered primarily a waterproofing job.

A short, stiff-bristled brush is the best tool for paint application.

Surfaces should be damp when paint is applied.

Cement paint should be cured as carefully as concrete.

Homes of Concrete Masonry

Duplex home in Atlanta, Georgia, with concrete brick walls in natural grey color.

Ralph Seymour, owner, Darien, Conn.—Fred J. Wallis, architect and builder, Westport, Conn.

Miami Beach, Fla.—Lester F. Preu, builder.

Wm. S. Doxey, owner, Coral Gables, Florida.
Wm. Shanklin, Jr., Miami, Fla., architect.
Boylan and Dietz, Miami, Fla., builder.

Harold Hicks residence, Palm Springs, Calif.—Lee Fuller, architect, Santa Monica

August Schram, owner, Seaford Manor, Long Island—Richard Heidelberger, architect, Seaford Manor, L. I., N. Y.

Harry Smith, Jr., owner, White Plains, N. Y.—Earl Nelson, architect, Homecrafters Service, Yonkers, N. Y.

Detroit, Mich.—Max Colter, Detroit, builder.

R. S. Gehlert residence, Grosse Pointe, Mich.

Park Ridge, N. J.—Atkins Bros., owners and builders, Montvale, N. J.

M. R. Gibbons, owner, Cleveland, Ohio—Carlton S. Crothers, Chagrin Falls, Ohio, designer

Detroit, Michigan—Albert Bill, Detroit, designer and builder.

Excellent Performance of Concrete Masonry In Severe Wind Storms

Why does concrete masonry construction successfully withstand severe wind storms?

The Florida hurricane in 1926 was a severe test of all types of construction. The many concrete masonry structures which suffered little or no damage in this storm furnished conclusive proof of the exceptional stability of properly built concrete masonry walls. In Coral Gables, a residential community near Miami, well-built concrete masonry fully demonstrated its storm-resisting ability.

According to engineers, Coral Gables was centrally located in the path of the hurricane. This storm, in the opinion of R. W. Gray, weather observer at Miami, exceeded all prior hurricanes in the United States from the standpoint of severity. The wind velocity was 125 miles per hour. A deluge of rain, amounting to between 8 and 15 inches in 16 hours, fell during the storm.

At the time of the hurricane, Coral Gables contained some 2500 residences, apartments and other buildings, all of which had concrete masonry walls. These buildings, erected in accordance with provisions of the local building code, came through the storm without a single case of destruction and with but slight damage.

The splendid showing of concrete masonry was described in an official statement by the Coral Gables Corporation: "A careful survey just completed by the city of Coral Gables, the Coral Gables Corporation, and the Chamber of Commerce of the city of Coral Gables reveals that the hurricane, which visited this section of Florida, Sept. 18, did less damage in the city of Coral Gables than in any other section of the Greater Miami district. One reason for this is that all buildings in Coral Gables are of concrete or tile construction (concrete masonry), which was better able to withstand the force of the storm than frame construction."

George E. Merrick, president, Coral Gables Corporation, in commenting on the storm, wrote: "Coral Gables, wisely restricted to concrete construction, withstood the force of the gale. . . . The total damage to the entire city of Coral Gables will not exceed $1,500,000 or about 1 per cent of the amount of money that has been spent in Coral Gables in construction and development."

Mr. Merrick was speaking of concrete masonry when he said concrete construction because, at the time, concrete masonry had been used in 93 per cent of the buildings in Coral Gables.

It has been conservatively estimated that the use of concrete masonry in Coral Gables resulted in a saving of between $25,000,000 and $50,000,000—that is, the storm damage would have reached that staggering figure had the buildings in Coral Gables been of similar construction to those surrounding the city on all sides.

When the Coral Gables project was started, a definite code was adopted which is in practical conformity with the recommendations of the Building Code Committee, U. S. Department of Commerce. The quality of mortar was definitely regulated, the specification for portland cement mortar requiring 1 part portland cement and not to exceed 3 parts sand, by volume; for portland cement-lime mortar, 1 part portland cement, 1 part slaked lime, and not more than 6 parts sand, by volume. Under the provisions of the code, anchoring of roofs and tying-in of floors are required.

A study of failures in all types of structures throughout the storm area showed that disasters like that which occurred in Florida can be prevented by the adoption of adequate codes based on approved standards, such as the recommendations of the Building Code Committee, U. S. Department of Commerce, and the strict enforcement of these codes. Coral Gables, with 93 per cent of its buildings constructed with well-built concrete masonry, is an example.

Quality concrete masonry units, properly laid in portland cement or portland cement-lime mortar, will result in structures that have remarkable storm-resistant properties.

Fig. 23. Distinctive in appearance and eliminating distracting noise. This office of concrete masonry units—laid in ashlar design—provides an atmosphere conducive to concentration and efficiency.

Concrete Ashlar Walls

A MODERN development in the masonry field is ashlar construction using concrete masonry units, either in standard sizes or in a combination of standard and fractional sizes.

Ashlar construction is known as coursed ashlar when the units are arranged according to height to form regular courses in the face of the wall. It is called random ashlar when several sizes of units are laid up at random. It is called patterned random when the units are laid apparently at random but actually are laid to a definite pattern which is repeated again and again in the face of the wall.

Architectural Treatment

Concrete ashlar offers many possibilities for architectural treatment. In fact, architects can achieve practically any effect desired, since concrete ashlar permits the use of color and the development of textures in addition to a wide choice of patterns, limited only by the ingenuity of the designer.

Color can be introduced by using selected aggregates in the facing of the units when they are manufactured, or by using mineral pigments in the concrete from which the units are molded. Also, the units can be stained or colored with portland cement paint as they are taken from the machine, or the finished walls can be suitably colored with portland cement paint or with stains.

Practically any texture desired from smooth to a rough, open texture can be produced by the proper selection and grading of aggregates in designing the concrete mixture, or by brushing, scoring or otherwise texturing the faces of the units while they are in a plastic condition.

Painting Concrete Ashlar

For both interior and exterior walls a very attractive finish is secured by means of portland cement paint which is available in a wide selection of colors. The paint may be used in one color, in two colors, or in several blending colors.

A pleasing two-tone effect is produced by spraying the entire surface with portland cement paint and then touching the high spots with a paint of a different color, usually of a lighter tint. For interior work, where it is desired to preserve the beauty and the natural acoustical properties of open-textured concrete ashlar, the paint is applied in such a manner that it coats the entire surface

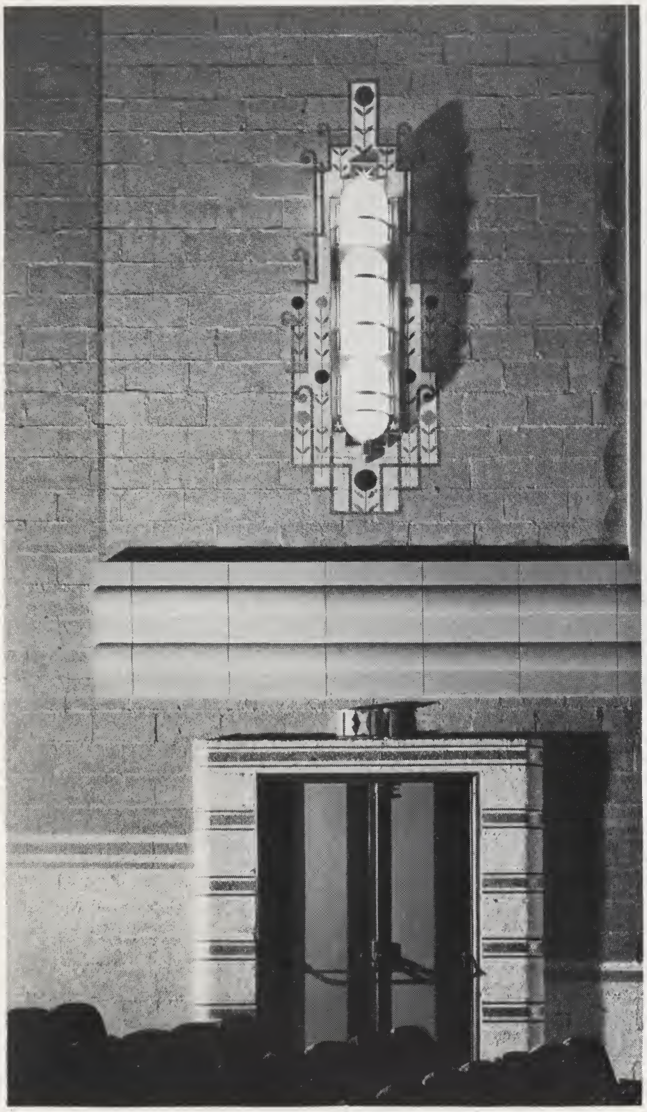


Fig. 24. Will Rogers Theatre, Chicago. Light-weight concrete masonry units not only provide a beautiful interior but also give desirable acoustical properties.

without filling the tiny depressions which serve to absorb sound waves. Where a two-color finish is desired, the second coat is brushed on the surface, but not in the depressions which retain the tone of the first coat. The general color of the wall is that of the second coat of paint, but the innumerable openings in the surface show through the second coat to provide an interesting two-tone effect as well as to emphasize the texture.

Variegated effects are produced by spraying the faces of the concrete units with portland cement paints of different colors which blend well together.

Several stains have been developed, some of which are sprayed on the faces of the units as they are taken from the mold box while others are applied after the walls have been erected and dried out.

Acoustical Treatment

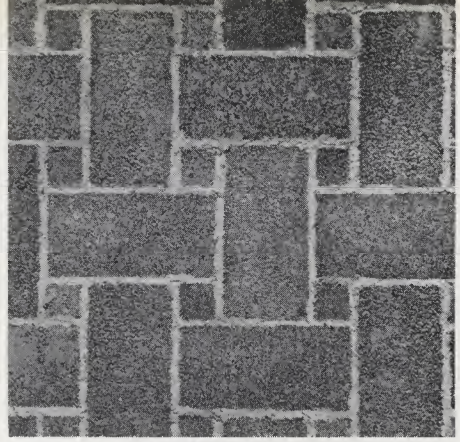
Open-textured concrete ashlar walls have desirable acoustical properties which make them especially suitable for walls in class rooms, auditoriums, hospitals, offices, private homes and in many other types of buildings. To have good acoustics there must be no tendency to echo. This is accomplished by constructing walls of a material which absorbs rather than reflects sounds. The numerous tiny depressions in open-textured concrete ashlar absorb sound waves, making it a satisfactory acoustical material.

Concrete Ashlar Patterns

Several concrete ashlar patterns are shown on pages 41 and 71. Many other interesting patterns can be worked out by using only a few sizes of units. Mortar joints also may be handled to produce various effects, depending upon the thickness of the joints, the manner in which they are struck and the color of the mortar used. Joints may be ¼ to 1 in. thick. They may be struck flush with the wall surface, raked or tooled, left rough in the adobe manner, or treated in other ways which the architect may devise. The color range is unlimited.

It is recommended that standard sizes of concrete masonry units or fractions thereof be used wherever possible in ashlar work. The fewer sizes used, the greater the economy of the wall construction. Most manufacturers of concrete masonry units are equipped to produce standard sizes and a number of fractions which may be worked into coursed or random ashlar patterns.

COURSED ASHLAR



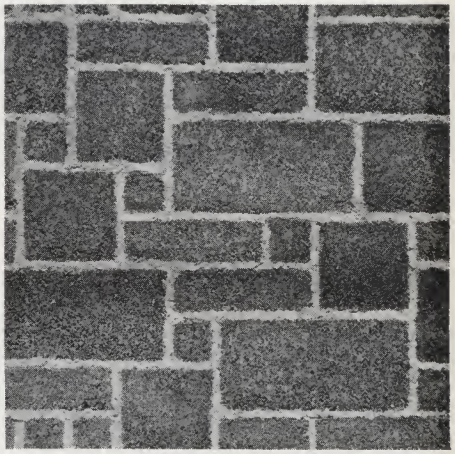
RANDOM ASHLAR

RANDOM AND COURSED

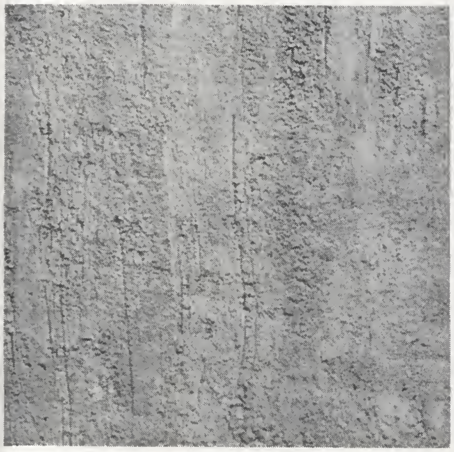
COURSED ASHLAR

ASHLAR

Increasingly popular is the use of concrete ashlar walls. Ashlar walls are built with one or more sizes of masonry units combined to form attractive patterns. Coursed ashlar is so called because it has continuous horizontal joints; random ashlar has neither continuous horizontal nor vertical joints. Attractive finishes can be secured by means of portland cement paint—available in a variety of colors. There are many more ashlar patterns available than can be shown here. Design details for several typical patterns are shown on page 71.



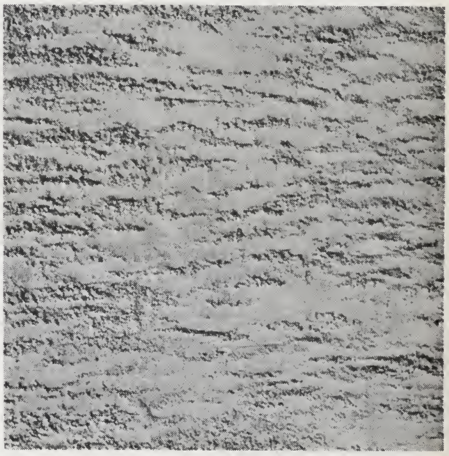
RANDOM ASHLAR



MODERN AMERICAN

STUCCO

No other material offers the great variety of pleasing and effective exterior surface treatments that are obtainable with portland cement stucco. Textures shown here are but five among many stucco surface treatments, all of which can be produced with equal facility by stucco craftsmen. The selection of textures here demonstrates their adaptability to various architectural styles. Textures may be given additional charm through the use of a wide selection of fast color finish coat stuccoes.



TRAVERTINE

Berks County Prison, Reading, Pa. Textured and colored concrete ashlar units used for exterior walls.

arborview Hospital, Seattle, Wash. Over 175,000 concrete masonry units used for back-up.

East Detroit Theatre, Detroit, Mich. Exposed concrete ashlar interior walls. A structural material having great acoustical and decorative value.

Valleyfield Cathedral, Valleyfield, Quebec. Concrete ashlar units used for all interior walls insure quiet and dignity.

Concrete Masonry Is Widely Recognized In Building Codes

THE inclusion of concrete masonry in leading building codes throughout the country is a strong endorsement for this building material.

Before a product is included in building codes, it must first demonstrate fully its suitability for building construction. Codes are drafted by committees of men who are impartial in their consideration of construction materials, their sole object being to draft regulations which will result in the construction of buildings that will safeguard lives and property. The use of safe, dependable construction materials is assured by imposing certain requirements which must be met before their use is allowed.

Codes Control Quality

In the case of masonry units of all types, building codes control quality by requiring that the units satisfactorily pass certain strength and absorption tests. The strength test is a measure of the unit's ability to sustain loads and the absorption test furnishes a measure of the material's ability to resist weather. The absorption test often is waived when units are to be used in walls which will not be exposed to the weather.

Status of Concrete Masonry

The status of concrete masonry in building codes for all cities in the country having 200,000 or more people is shown in Table 19. Requirements of the American Society for Testing Materials; Federal Specifications' Board; Building Code Committee, U. S. Department of Commerce; The National Board of Fire Underwriters; and Pacific Coast Building Officials' Conference are also included.

Information in Table 19

The first column of numerals gives the year the different codes were adopted or reprinted. In general, the more recent the code the more liberal are its provisions for concrete masonry units.

The second column in Table 19 gives the compressive strength requirements for concrete masonry units, gross area; the third column, the maximum allowable absorption. The next five columns list allowable working loads, wall thickness, and maximum wall height as prescribed in the different codes.

The last column denotes which codes permit the use of concrete masonry in fire and party walls. Due to the splendid performance of concrete masonry walls in standard fire tests, this type of construction is allowed for fire and party walls in the majority of leading codes. A discussion of the fire-retardant classification of concrete masonry walls is given in Section 9, "Concrete Masonry Is Excellent Fire Retardant."

Value in Building Codes

Strict enforcement of modern building codes raises construction standards, prevents the use of inferior building materials, places competition on a higher plane, gives an official stamp of approval on products meeting code provisions, and increases the confidence of everyone in the structural merits of materials.

Manufacturers of concrete masonry units, therefore, approve strict enforcement of modern building codes, and benefit by producing units which meet the requirements.

When a city lacks a modern code, the adoption of a fair, impartial ordinance often can be obtained by enlisting the active cooperation of building commissioners, other city officials, civic clubs, mortgage bankers, building and loan associations, and others interested in sound construction.

TABLE 19—Abstracts of Building Code Requirements for Hollow Concrete Masonry Construction

Code	Date of Code	Hollow Concrete Unit Requirements: Comp. Str. Gross Area p.s.i.	Hollow Concrete Unit Requirements: Absorption per cent or lb. per cu. ft.	Allowable Working Stress p.s.i. or per cent	Bearing Walls: Min. Thickness in.	Bearing Walls: Max. Height ft. or stories	Foundation Walls Thickness: Dwellings in.	Foundation Walls Thickness: Other Buildings in.	Permitted In Fire or Party Walls
National Specifications									
A.S.T.M. Spec.	1931	700	15 lb. (2)	—	—	—	—	—	—
C90-39		1000 (4)	15 lb. (2)	—	—	—	—	—	—
Federal Spec.	1931	700	16 lb. (2)	—	—	—	—	—	—
SS-C-621		1000 (4)	16 lb. (2)	—	—	—	—	—	—
National or Sectional Codes									
U. S. Dept. of Commerce	1925	700	10% (1) (2)	80	8	50	12 (7)	12 (7)	Yes
Nat'l Bd. Fire Underwriters	1934	700	10% (1) (2)	80	8	40	10	10	No
Pacific Coast Bldg. Officials	1937	700	15 lb. (2)	80	6	—	8	12 (7)	Yes
		1000 (4)							
All Cities Over 200,000 Population									
Akron	1929	780	7%	200 (6)	8	3–S	8	12	Yes
Atlanta	1924	800	10%	80	8	40	12	12	No
Baltimore	1928	750	12%	10%	8	35	No	No	Yes
Birmingham	1929	1400	16%	80	8	5–S	—	—	No
Boston	1926	1000	12%	100	8	3–S	12	12	Yes
Buffalo	1924	2000 (6)	—	150 (6)	8	3–S	12	12	Yes
Cincinnati	1937	1000 (5)	14 lb.	80	8	—	8	8	Yes
		750 (8)							
Chicago	1937	700	15 lb. (2)	80	8	50	8	12	Yes
		1000 (4)							
Cleveland	1927	1200 (6)	6%	200 (6)	8	3–S	12	12	Yes
Columbus	1930	1000	10% (2)	200	8	—	8	8	Yes
Dallas	1929	700	10% (1)	80	8	—	8	12	Yes
		1000	8% (1)						
Dayton	1928	700 (8)	14 lb.	90	8	36	8	12	Yes (9)
		1000 (5)		120					
Denver	1935	700	15 lb. (2)	80	8	—	12 (7)	12 (7)	Yes
		1000 (4)							
Detroit	1936	700	15% (1)	90	8	40	8	12	Yes
Houston	1930	1000	8% (1)	80	8	—	8	12	Yes
Indianapolis	1926	800	14 lb.	10%	8	—	12	12	Yes
Jersey City	1907	1000	—	110	10	—	12	12	Yes
Kansas City	1927	750	14 lb.	75	8	40	12	12	No
Los Angeles	1930	1200 (6)	10%	—	8	35	No	No	Yes
Louisville	1926	700	10% (1)	—	8	40	10	10	Yes
Memphis	1930	1500 (6)	15%	10	8	—	—	—	Yes
Milwaukee	1922	700	8%	150 (6)	10	60	10	12	Yes
Minneapolis	1934	1000	8% (1)	80	8	3–S	8	12	Yes
Newark	1924	750	15%	75	8	40	12	12	Yes
New Orleans	1928	700	10% (1)	10%	8	40	12	12	Yes
New York	1938	700	—	10%	8	40	12	12	Yes
Oakland	1929	—	—	—	8	3–S	12 (7)	12	Yes
Omaha	1923	1000	10%	—	8	—	8	12	Yes
Philadelphia	1929	1000	—	80	8	4–S	No	No	No
Pittsburgh	1929	900	10% (1)	130	8	—	8	12	Yes
Portland	1931	1500 (6)	10%	80	8	—	8	12	Yes
Providence	1931	800	15%	10%	8	45	12	12	Yes
Rochester	1931	700	10% (1)	80	8	40	10	12	Yes
San Antonio	1913	—	—	—	—	—	—	—	—
San Francisco	1926	—	—	—	6	—	—	—	—
St. Louis	1928	—	—	—	—	—	—	—	—
St. Paul	1930	700	10%	200 (6)	8	—	12	12	Yes
Seattle	1924	1500 (6)	10%	300 (6)	8	—	12	12	Yes
Syracuse	1930	700 (3)	10%	75	8	60	8	8	Yes
		800	10%	100					
Toledo	1930	700 (8)	10% (1)	—	—	—	—	—	—
		1000 (5)							
Washington	1930	700	10% (1) (2)	80	8	50	12	12	Yes

(1) Higher per cent absorption permitted for light-weight concrete.
(2) Absorption requirement waived when not exposed to weather or soil.
(3) Cinder concrete units—800-p.s.i. requirement for sand block.
(4) For units with face shells less than 1¼ in. and more than ¾ in.
(5) For construction exposed to weather.
(6) Net bearing area.
(7) 8 in. when not excavated.
(8) Units not exposed to weather.
(9) Permitted for fire walls if faced with 4 in. of brick.

Construction Details

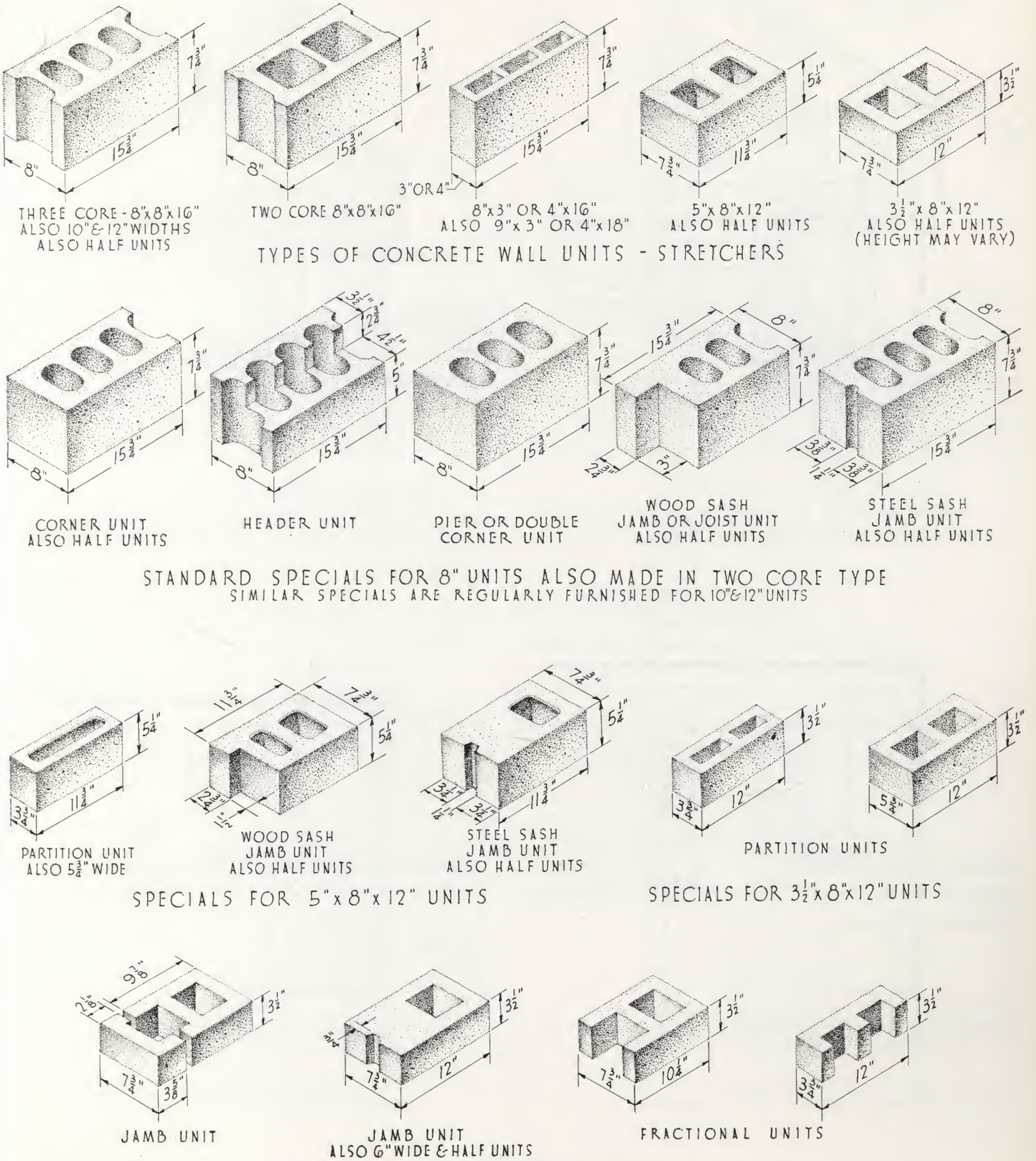
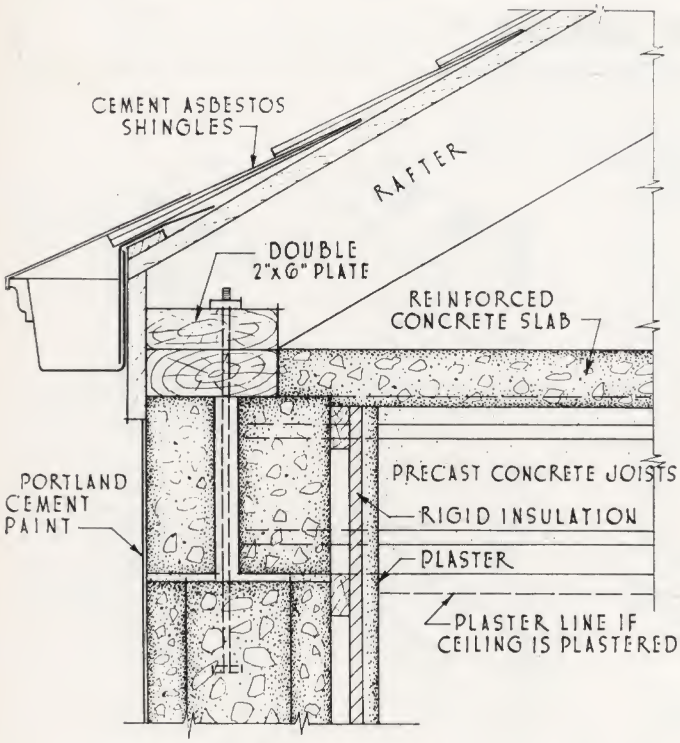
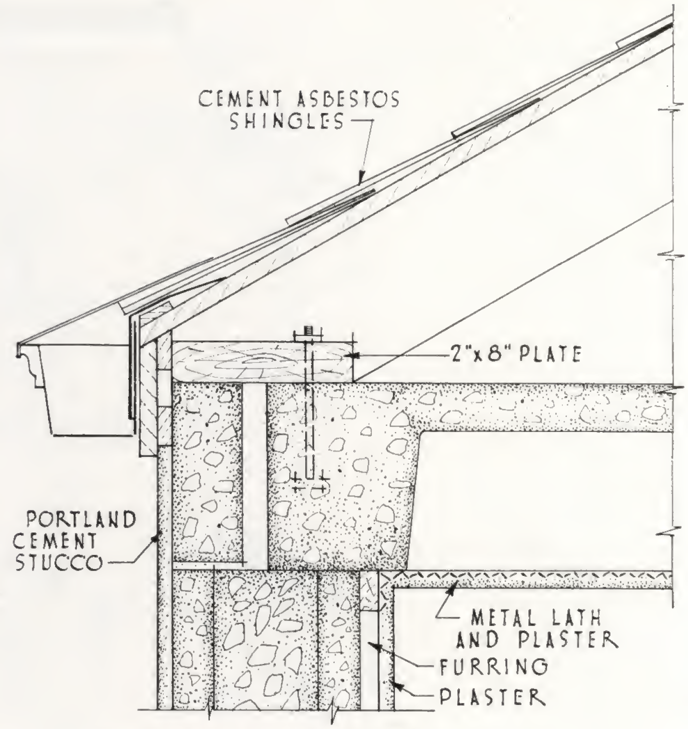


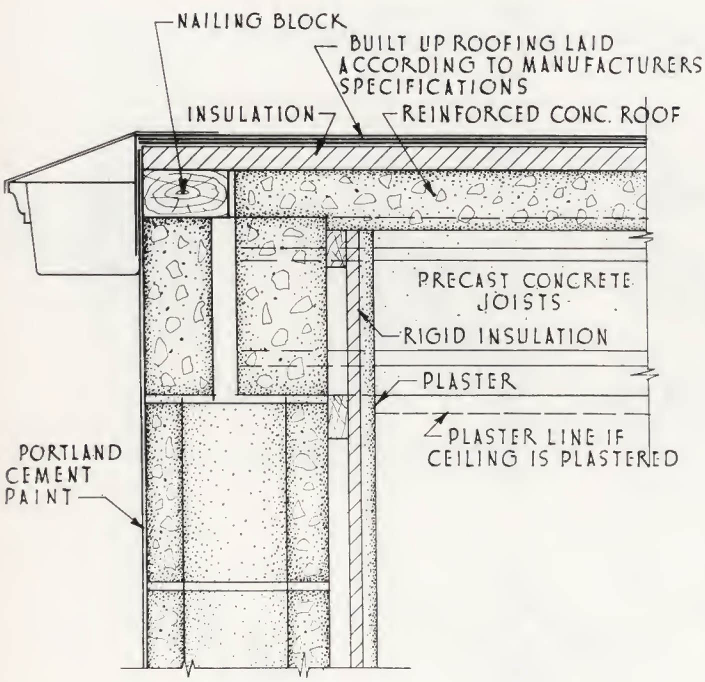
Fig. 25. Typical hollow concrete masonry units.



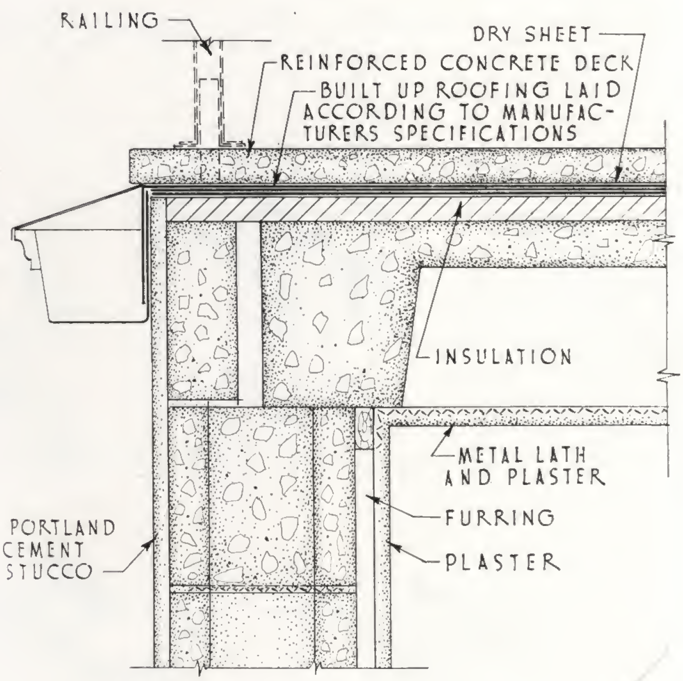
PITCHED ROOF DETAILS
8" CONCRETE MASONRY WALL - PORTLAND
CEMENT PAINT - PRECAST CONC. JOISTS



PITCHED ROOF DETAILS
8" CONCRETE MASONRY WALL - PORTLAND
CEMENT STUCCO - JOIST FLOOR CONST.

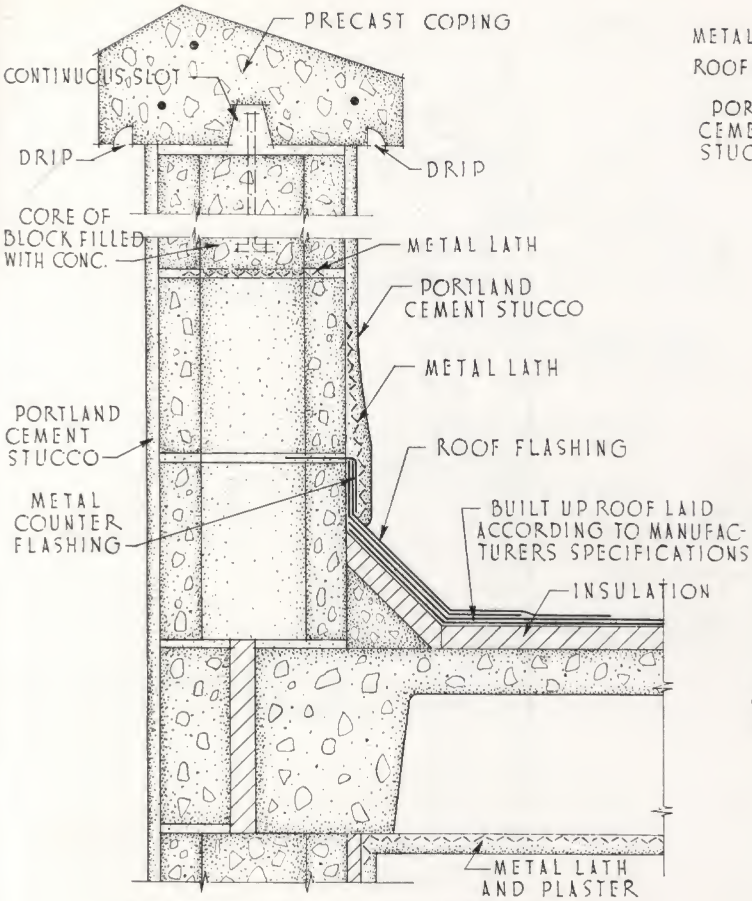


FLAT ROOF DETAILS
PRECAST CONCRETE JOISTS

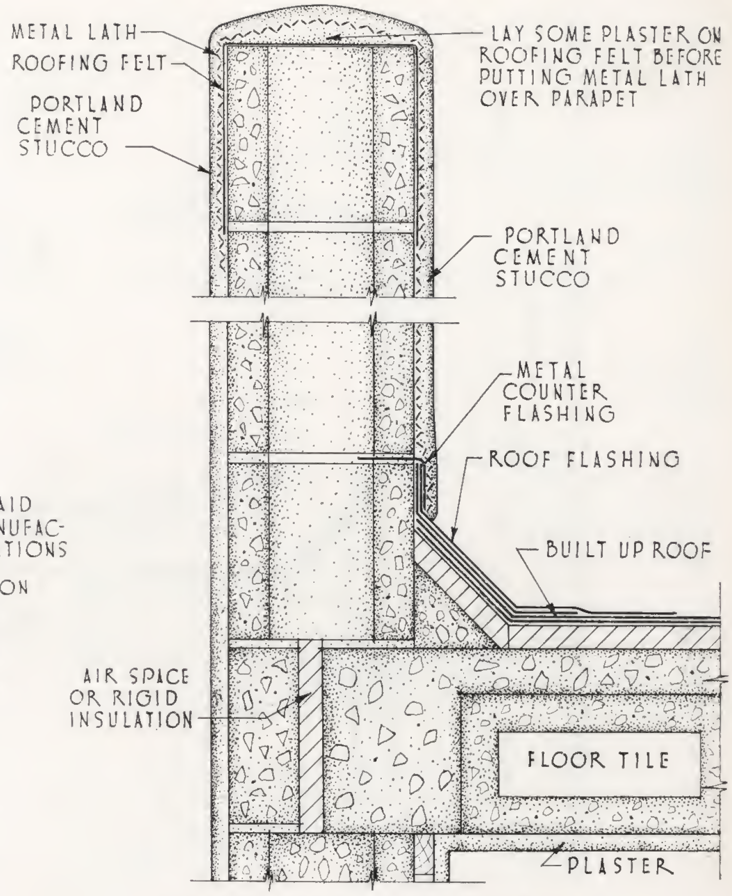


ROOF DECK DETAIL
JOIST ROOF CONSTRUCTION

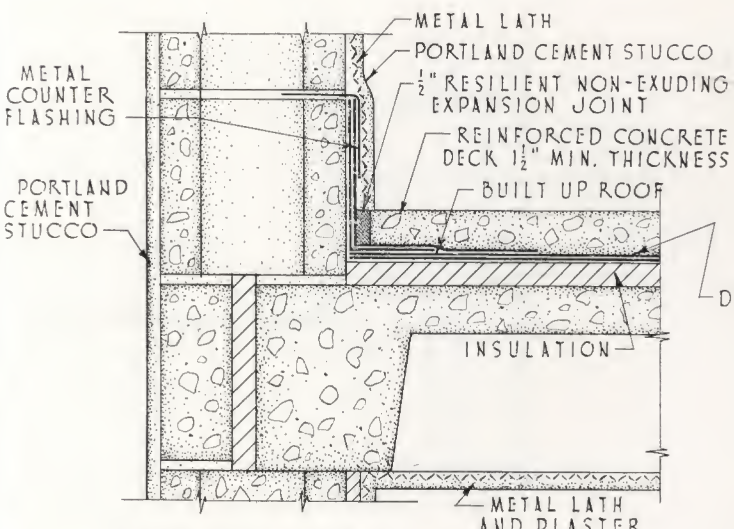
Fig. 26. Pitched and flat roofs.



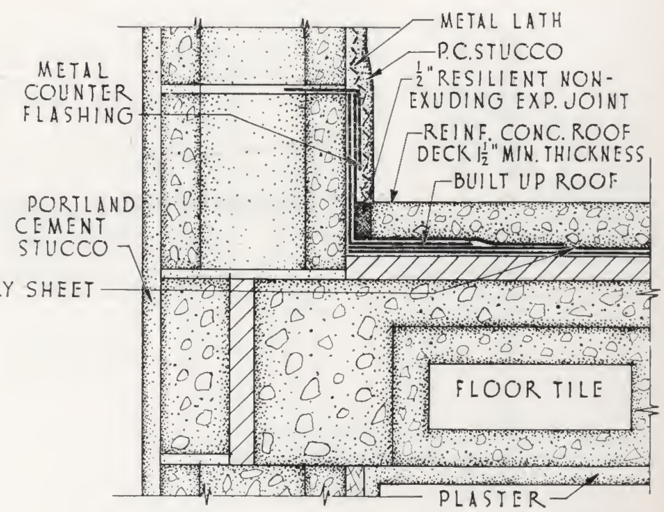
PARAPET AND ROOF DETAILS
8" CONCRETE MASONRY WALL - P.C. STUCCO
PRECAST COPING - JOIST ROOF CONST.



PARAPET AND ROOF DETAILS
8" CONCRETE MASONRY WALL - P.C. STUCCO
TILE AND JOIST ROOF CONSTRUCTION



ROOF DECK DETAIL
JOIST ROOF CONSTRUCTION



ROOF DECK DETAIL
TILE AND JOIST ROOF CONSTRUCTION

Fig. 27. Parapets—coping—flat roofs—decks.

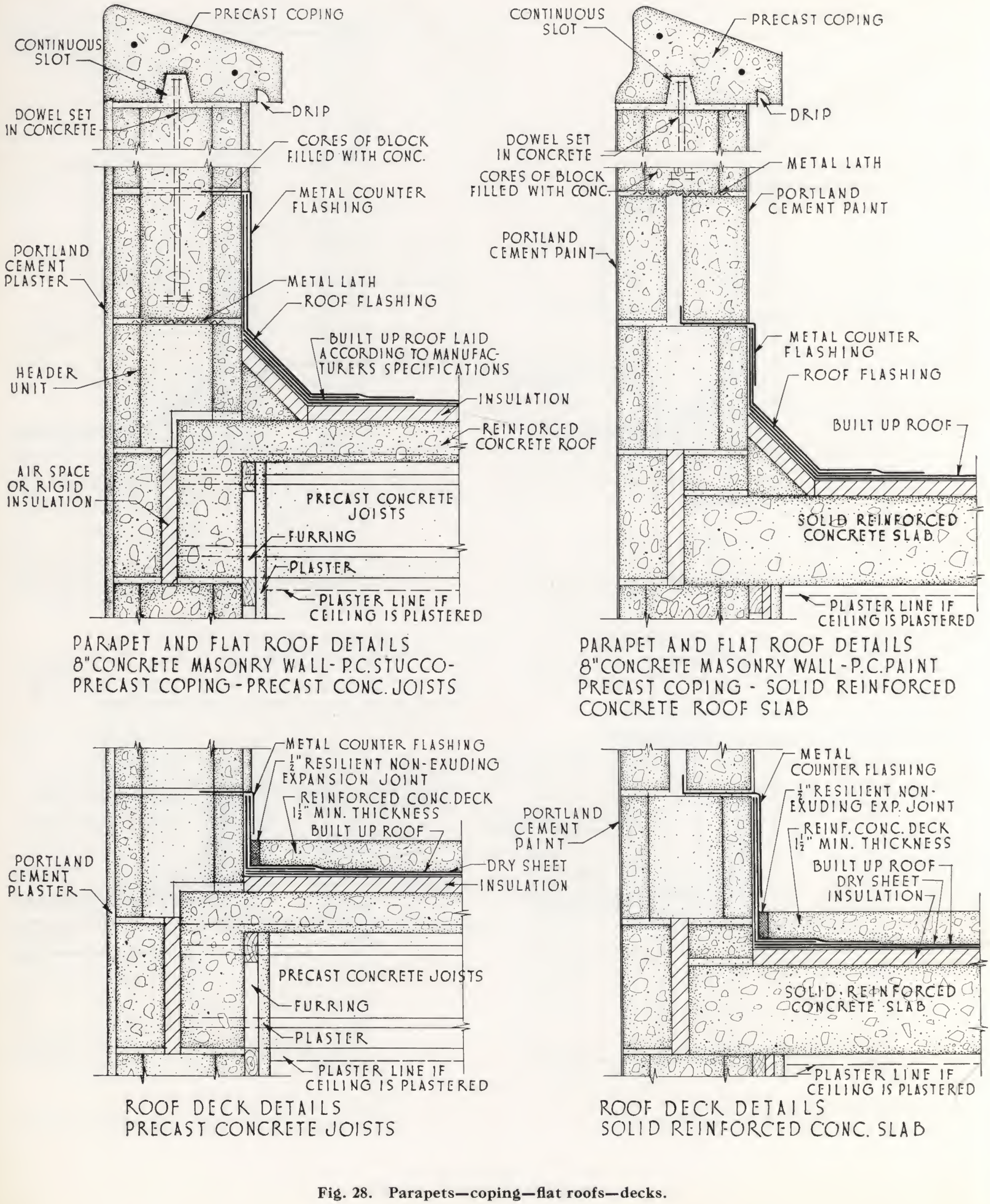
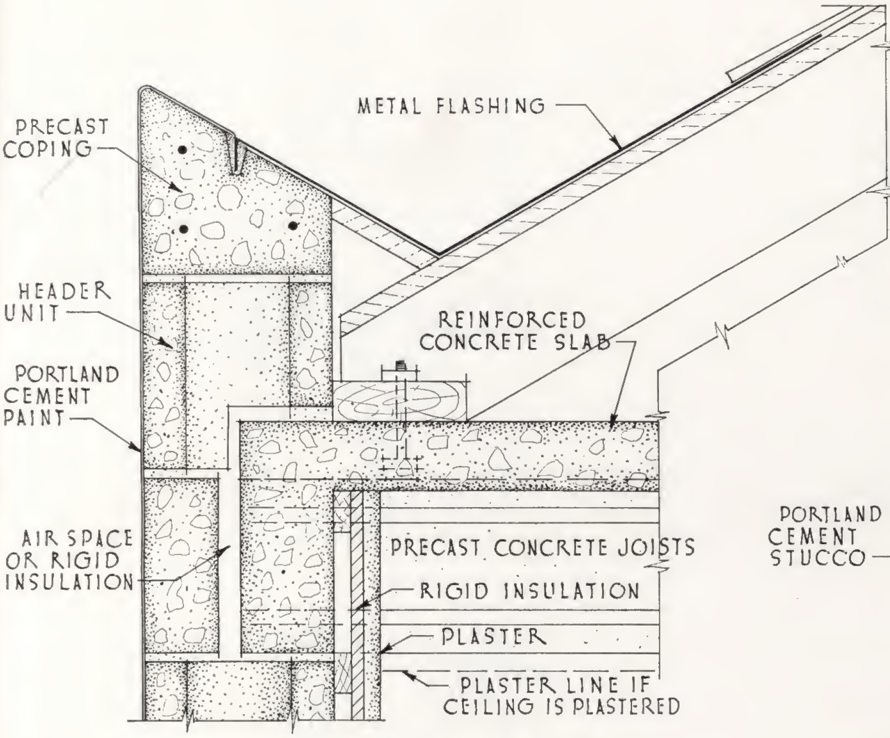
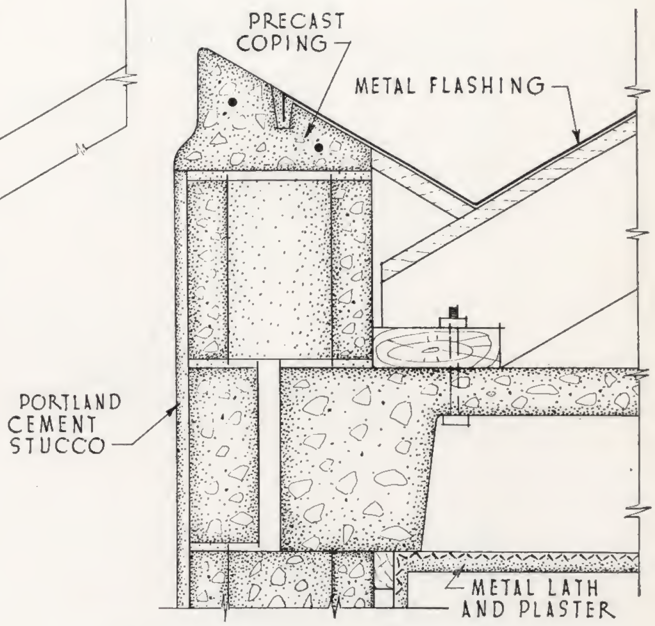


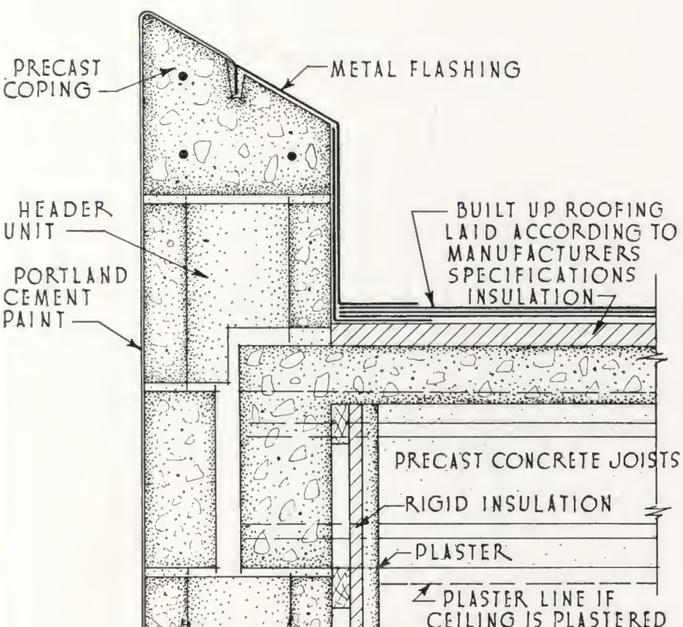
Fig. 28. Parapets—coping—flat roofs—decks.



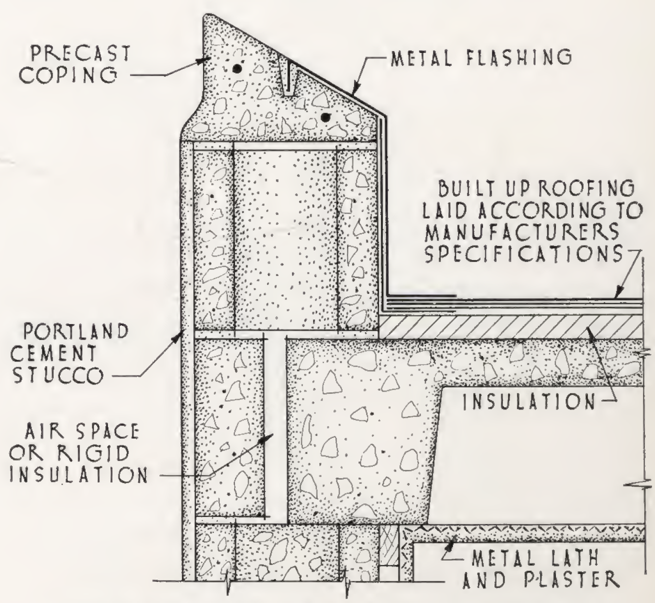
PARAPET AND PITCHED ROOF DETAILS
8" CONCRETE MASONRY WALL - PORTLAND CEMENT PAINT - PRECAST CONCRETE JOISTS



PARAPET AND PITCHED ROOF DETAILS
8" CONCRETE MASONRY WALL - PORTLAND CEMENT STUCCO - JOIST FLOOR CONST.



LOW PARAPET AND FLAT ROOF DETAILS
PRECAST CONCRETE JOISTS



LOW PARAPET AND FLAT ROOF DETAILS
JOIST ROOF CONSTRUCTION

Fig. 29. Low parapets with pitched and flat roofs.

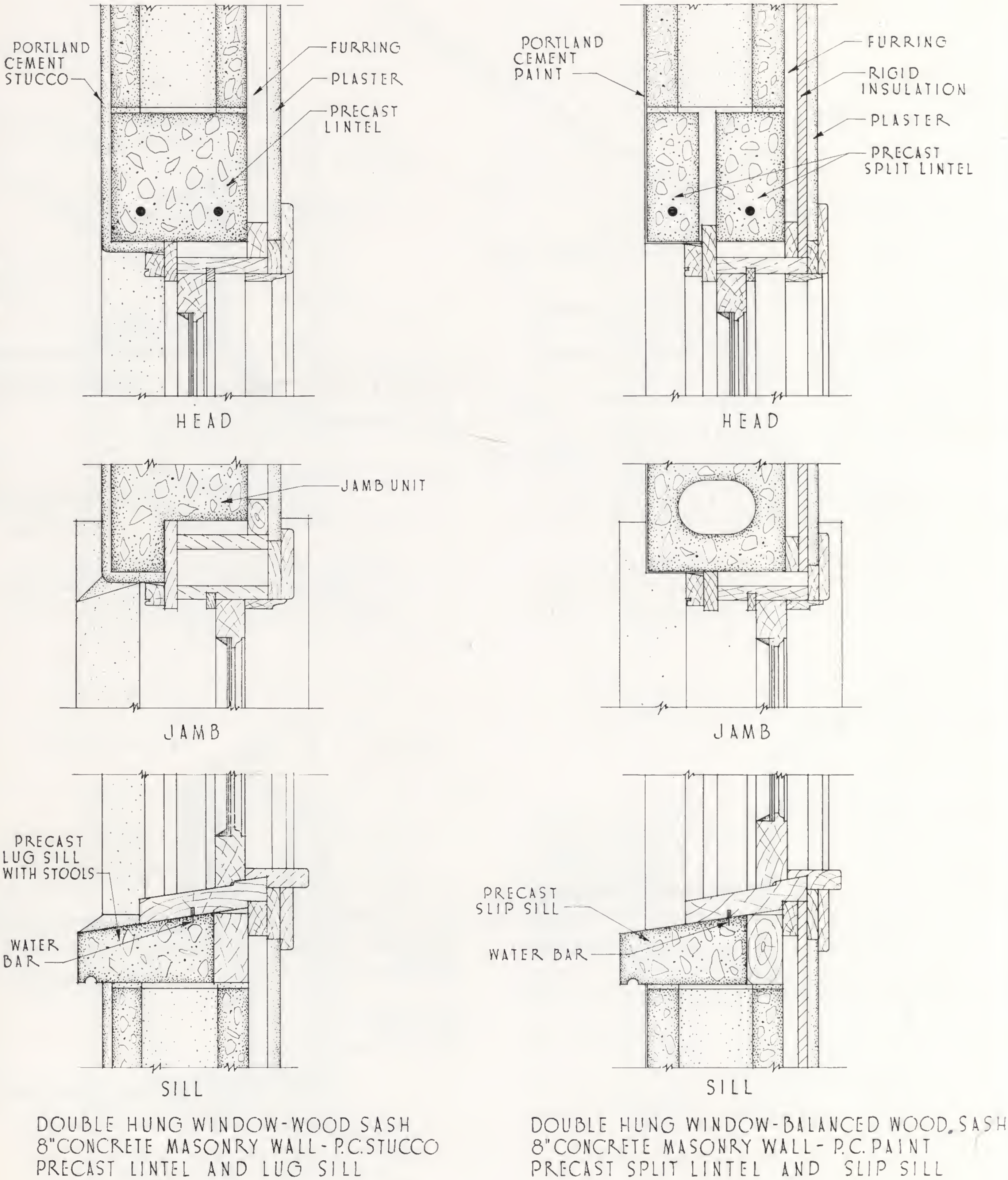
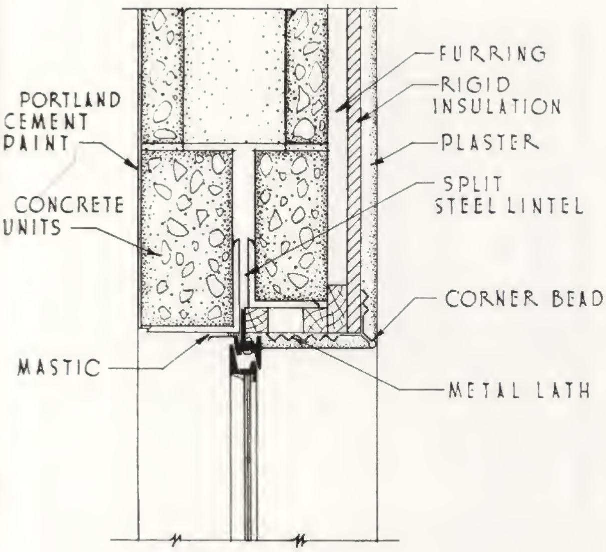
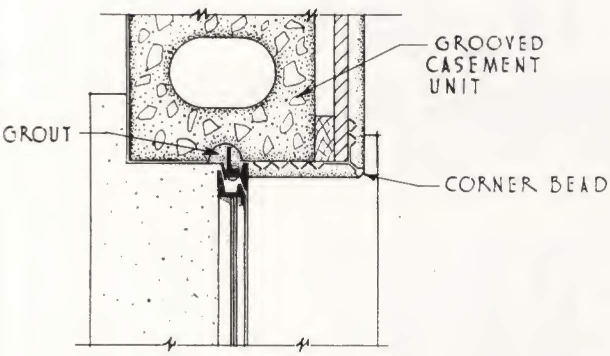


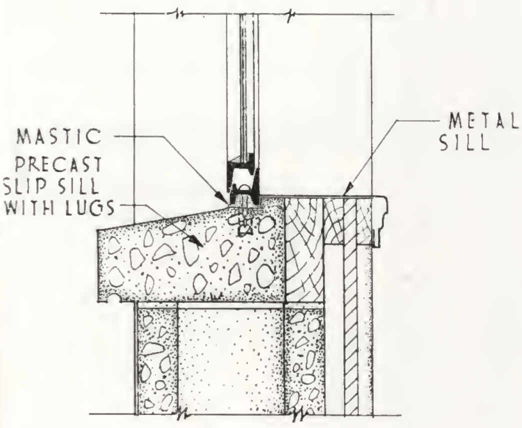
Fig. 30. Wood sash window details.



HEAD

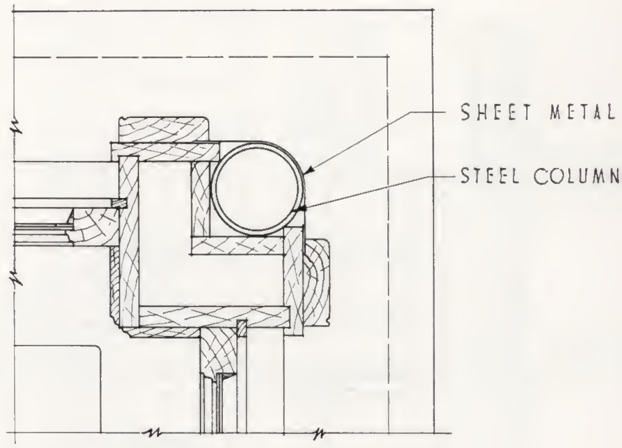


JAMB

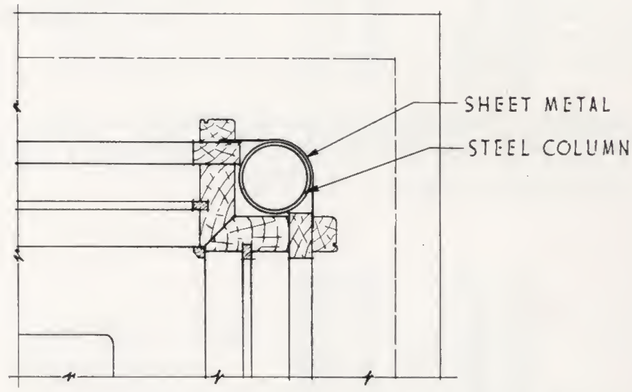


SILL

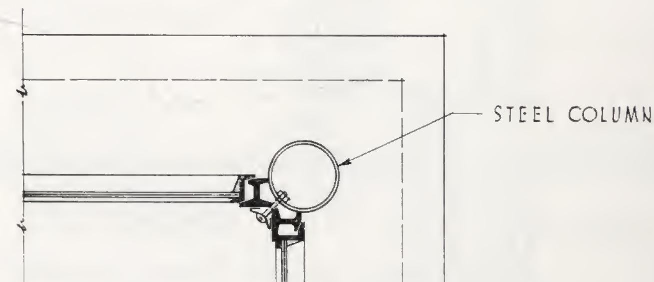
CASEMENT WINDOW - SWING OUT TYPE
STEEL SASH - 8" CONCRETE MASONRY WALL
P.C. PAINT - SPLIT STEEL LINTEL AND
PRECAST SLIP SILL



DOUBLE HUNG
CORNER WINDOWS
WOOD SASH



DOUBLE HUNG
CORNER WINDOWS
BALANCED WOOD SASH



CASEMENT CORNER WINDOWS -
SWING OUT TYPE - STEEL SASH

DETAILS OF CORNER WINDOWS

Fig. 31. Steel sash and corner window details.

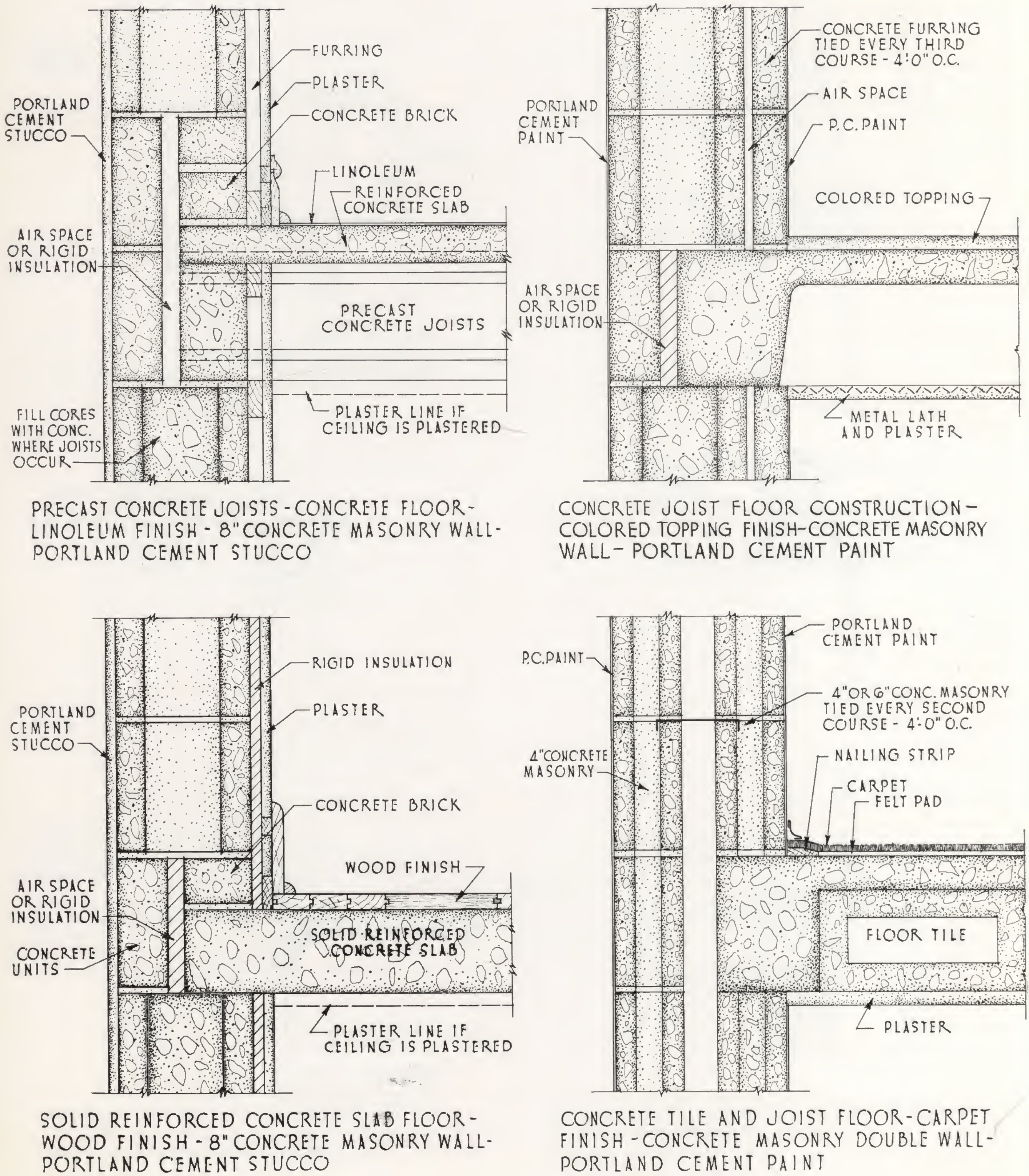


Fig. 32. Four types of concrete floors.

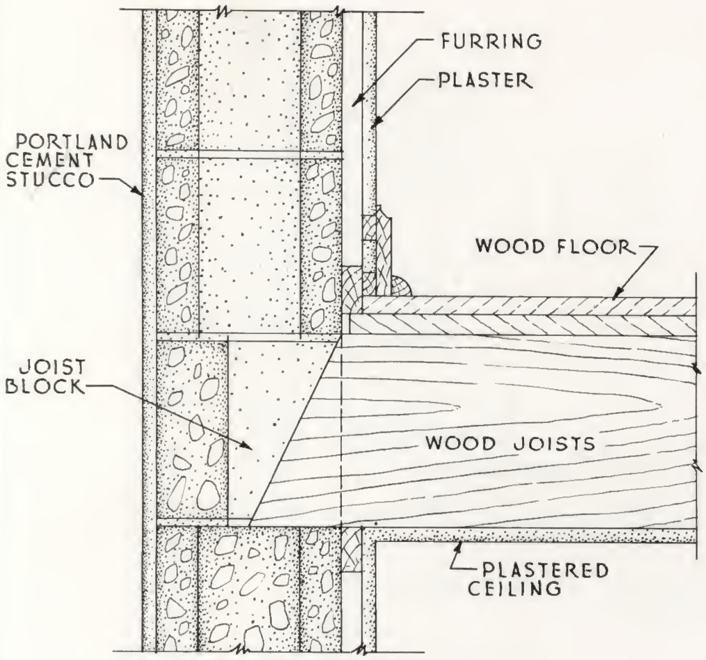


Fig. 33. Wood joist—wood floor finish—8-in. concrete masonry wall—portland cement stucco.

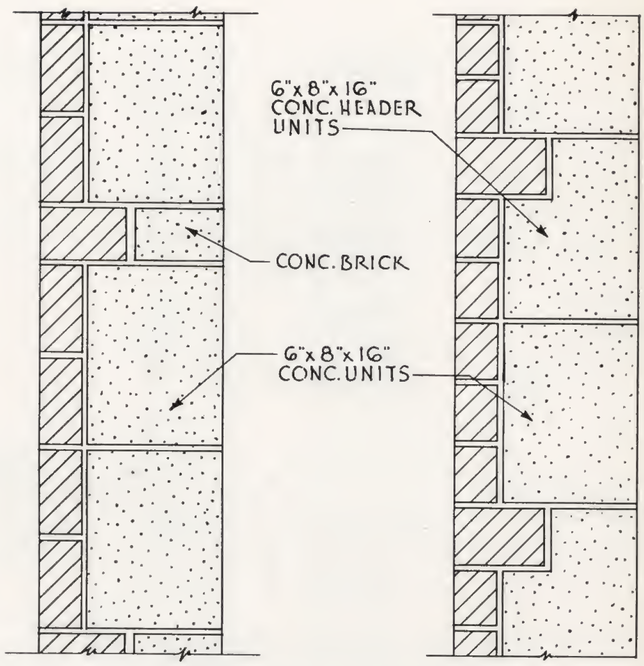


Fig. 34. Two new methods of bonding brick facing to concrete masonry to produce 8-in. walls.

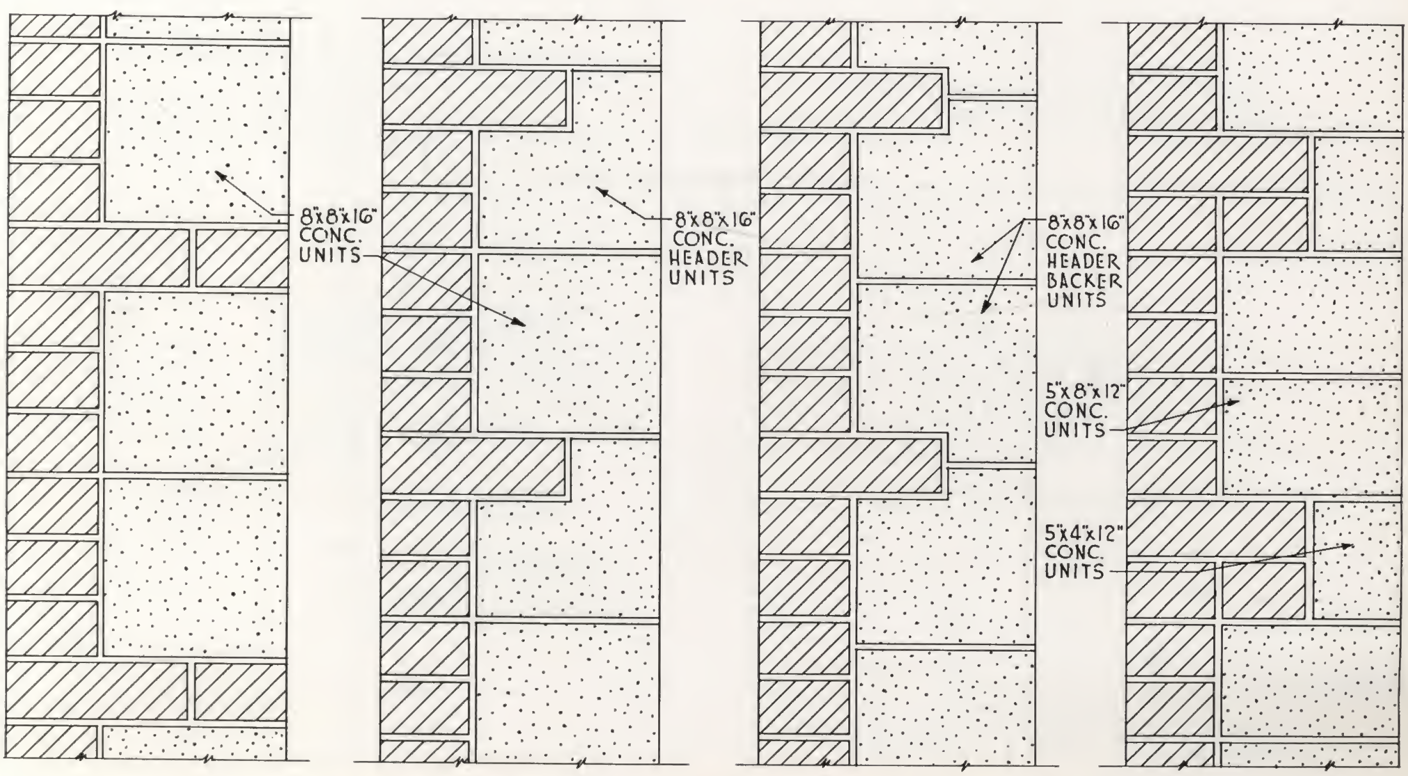


Fig. 35. Methods of bonding brick facing to concrete masonry wall.

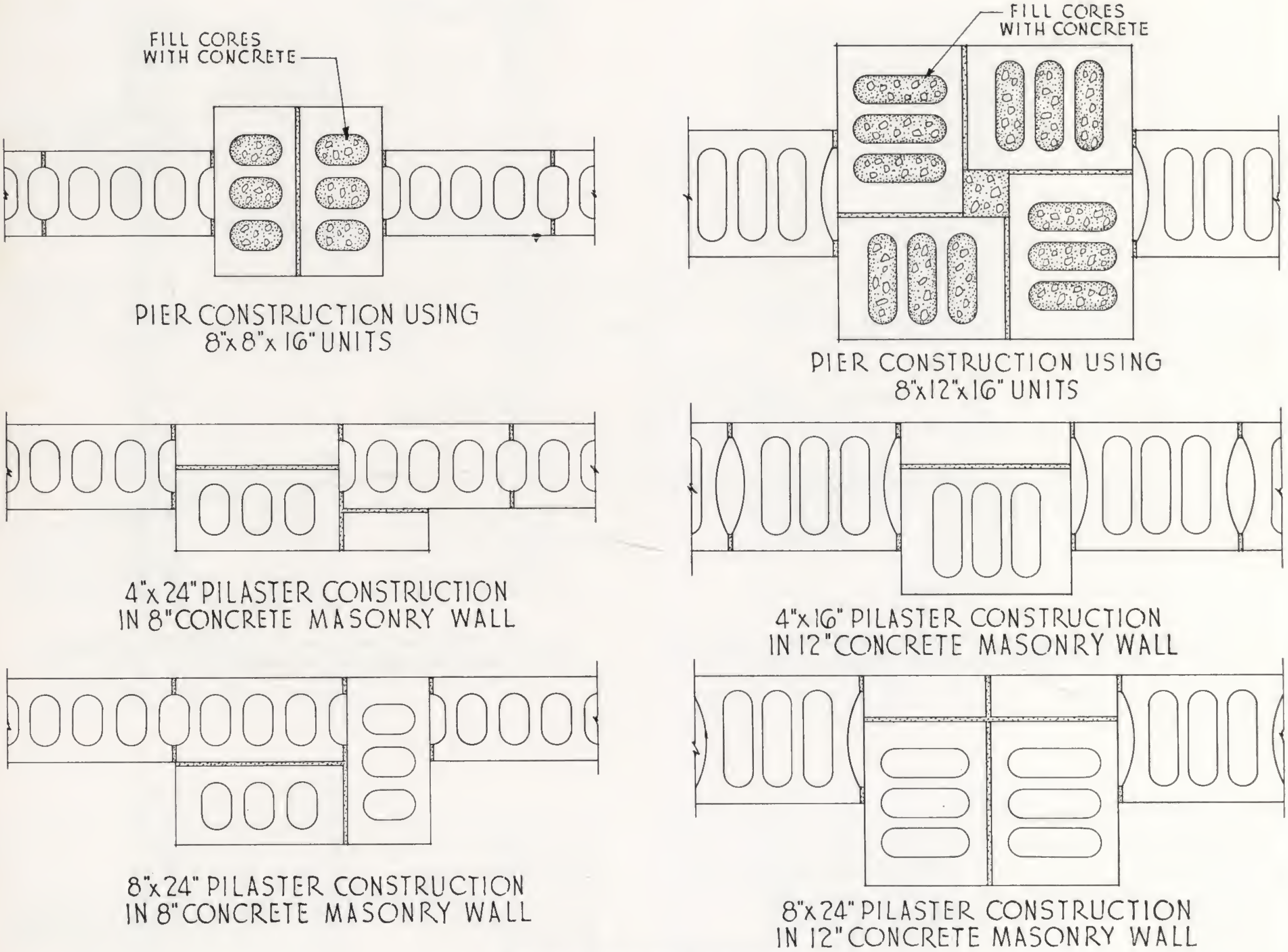


Fig. 36. Piers and pilasters.

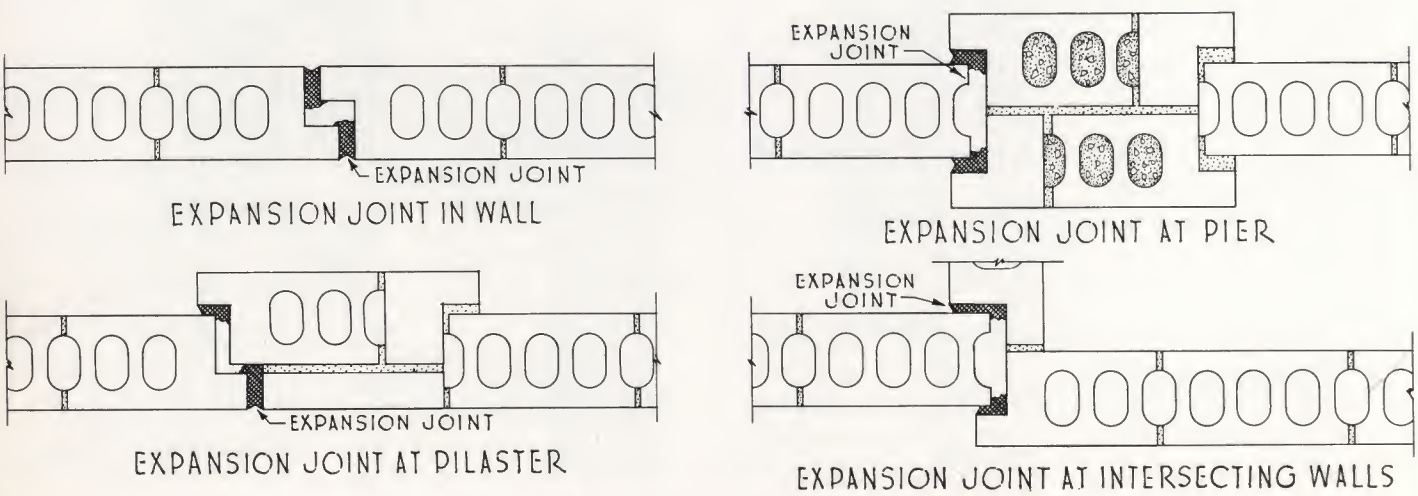


Fig. 37. Four types of expansion joints for concrete masonry walls.

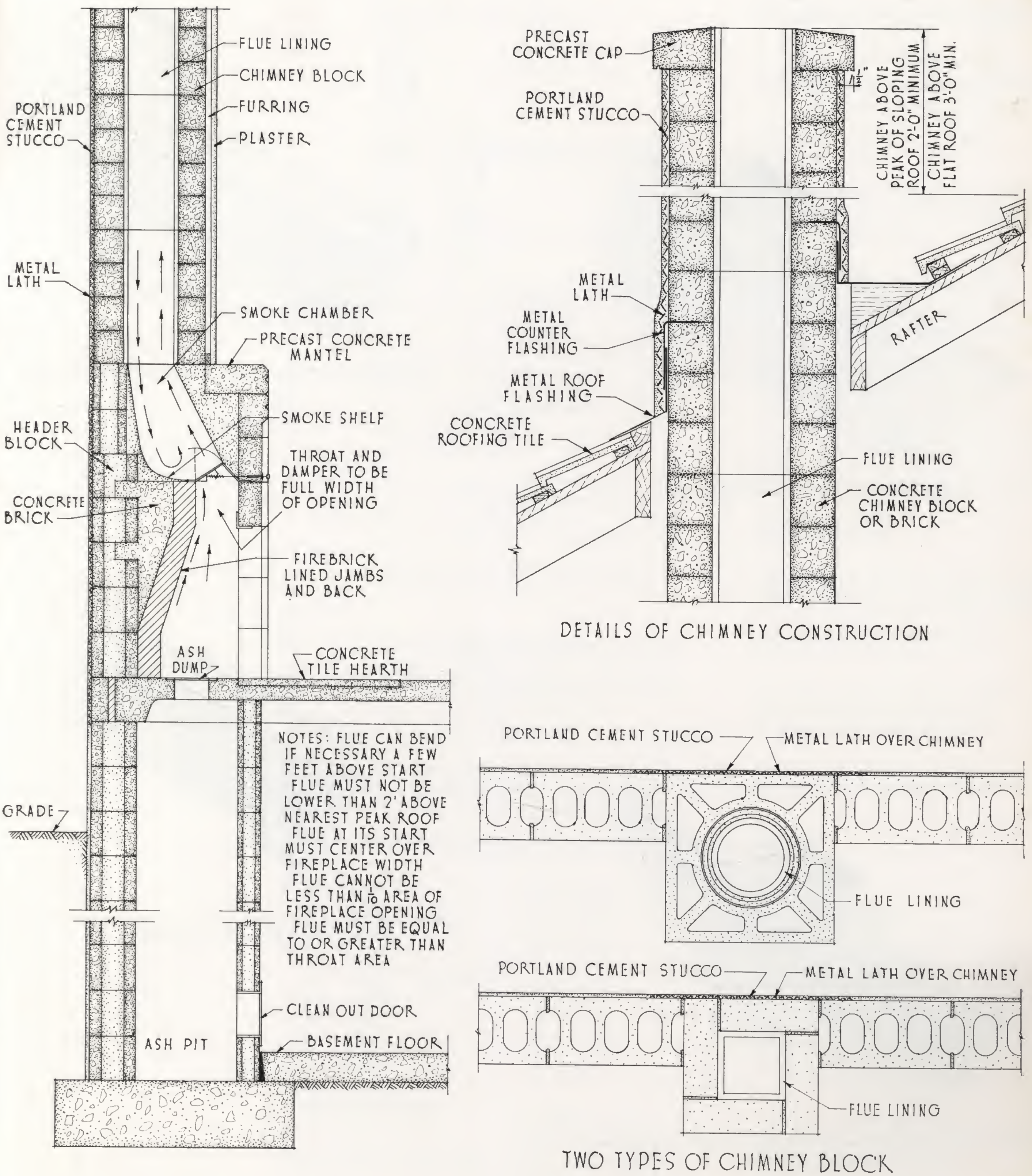
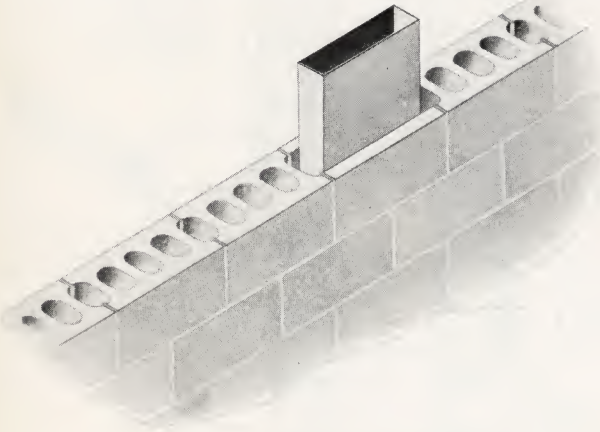
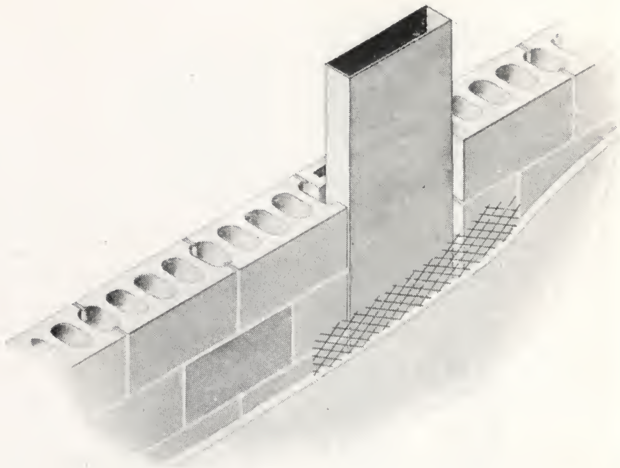


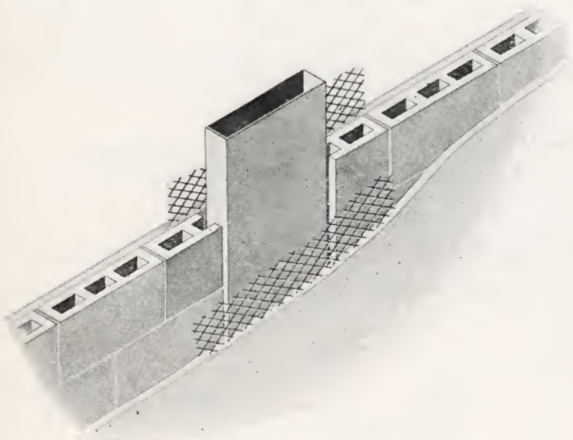
Fig. 38. Fireplace and chimney details.



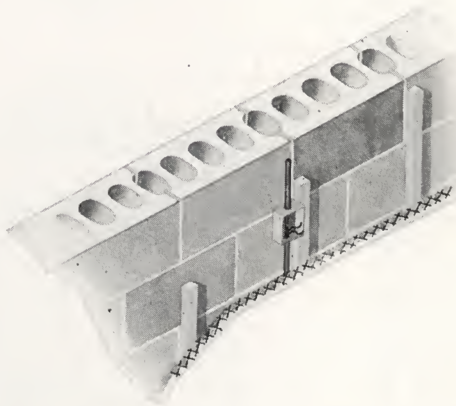
Heating duct in interior load-bearing wall.



Heating duct in exterior wall to be plastered direct on inside.

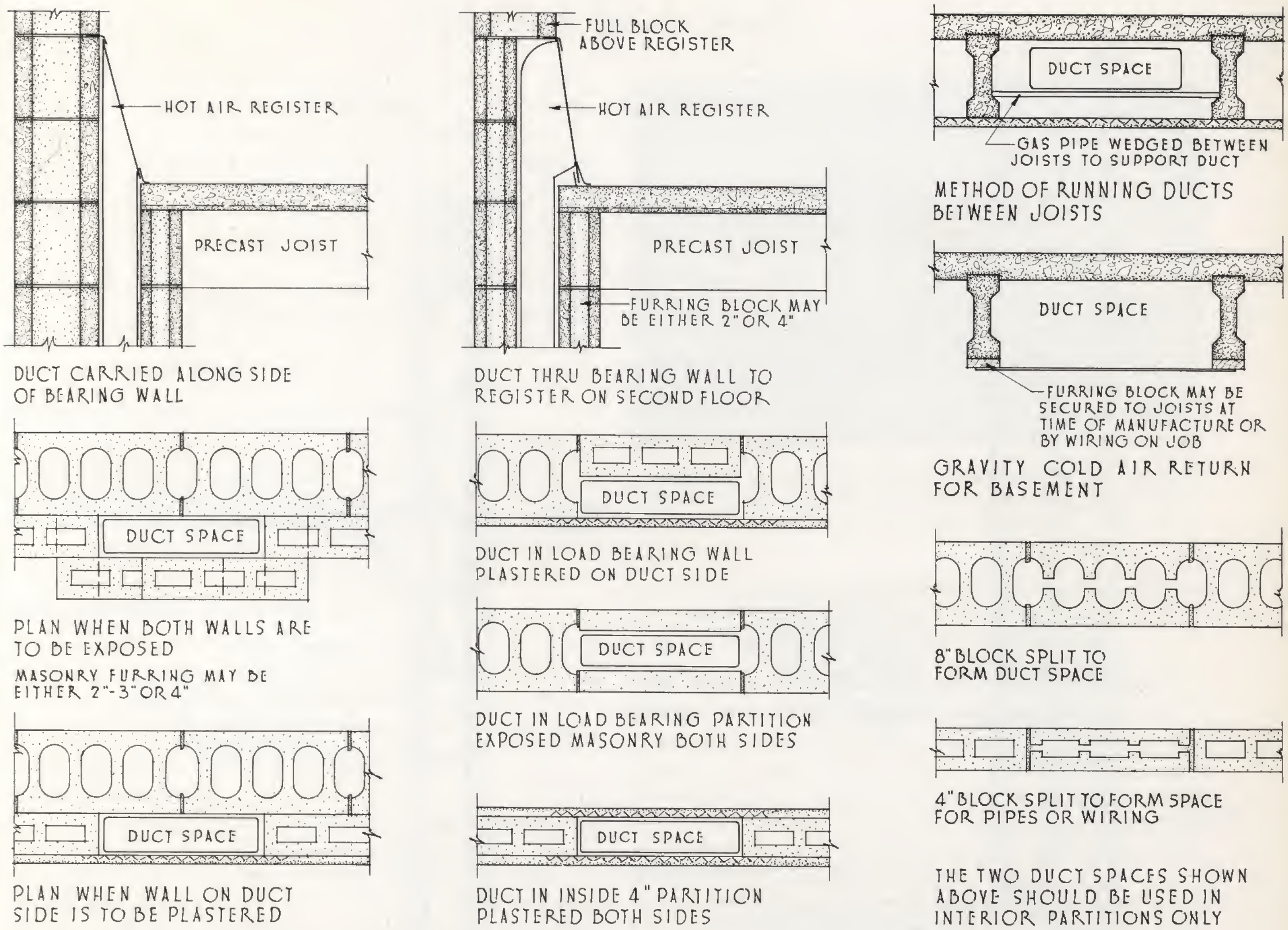


Heating duct in interior non-load-bearing partition to be plastered direct on both sides.



Typical method of installing electric conduit—concrete masonry wall furred and plastered.

Fig. 39. Typical methods of installing heating ducts and electrical conduits in concrete masonry walls.



WHEN KITCHEN AND BATH ROOM PIPING CAN BE COMBINED THEY MAY BE ENCASED IN A SHAFT EXTENDING FROM THE BASEMENT TO THE SECOND FLOOR. THIS SHAFT MAY BE BUILT IN THE BACK OF A CLOSET OR CUPBOARD AND IF CENTRALLY LOCATED MAY ALSO CARRY THE HEATING DUCTS AND WIRING

Fig. 40. Several methods of handling heating, plumbing and wiring lines.

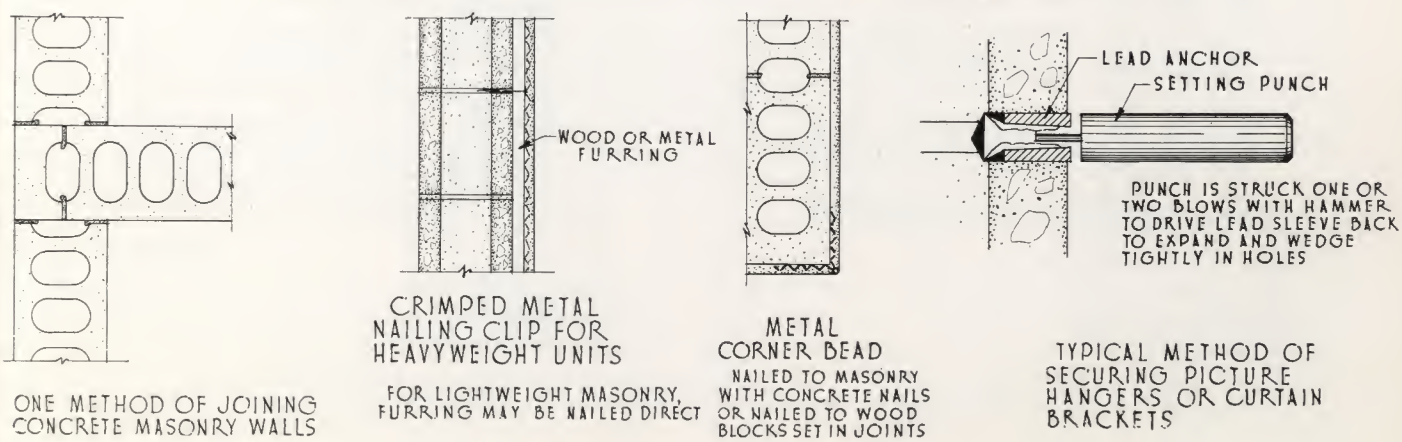


Fig. 41. Miscellaneous construction details.

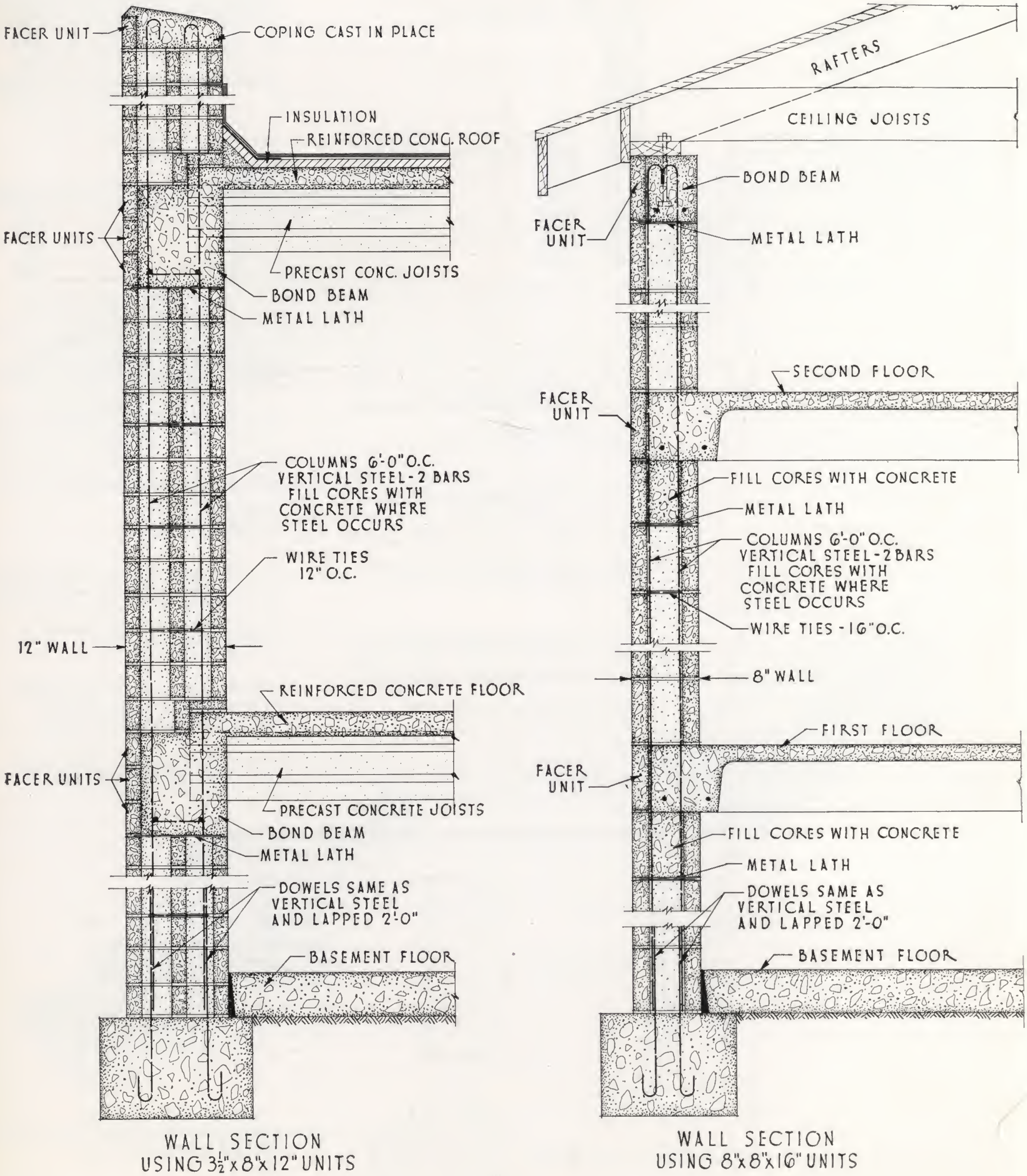


Fig. 42. Reinforced concrete masonry.

Concrete Brick Walls

CONCRETE brick are generally available for those who desire to use brick-size units. They are durable, fire-resistive and able to carry heavy loads. They also serve as an excellent paint base and, due to their true size and shape, lay into a wall with true even mortar joints. Concrete brick are used for both load-bearing and non-load-bearing walls, for party walls, as backing for various facing materials, for fireproofing, for decorative courses in concrete masonry construction, for building chimneys and fireplaces, and for almost every building construction where a brick-sized unit can be used to advantage.

Types and Sizes of Concrete Brick

Concrete brick are made of any of the commonly used concrete aggregates such as sand-gravel, cinders, expanded shale and expanded slag. Concrete brick are made in standard sizes, the single brick being 3¾ in. wide, 2¼ in. thick and 8 in. long, and the "Jumbo" brick 3¾ in. wide, 3¾ in. thick and 8 in. long.

Quality

Concrete brick made under modern production methods easily meet building code requirements as well as the specifications of the American Society for Testing Materials. The latter recommendations for concrete brick are summarized in the table on page 62.

Strength of Walls

Tests conducted at Columbia University showed that under average conditions, to produce walls of equal strength, clay brick units had to be about twice as strong as concrete brick units. The better performance for concrete brick was due to the superior bonding qualities of the concrete brick with the mortar, which is further evidenced by the manner of failure of piers in these tests. Concrete brick piers failed as a unit, the mortar providing a bond similar to that between mortar and aggregate in cast-in-place concrete. Clay brick piers, on the other hand, failed in detail, the bond between brick and mortar failing in a vertical plane tending to split the piers. This tendency of longitudinal splitting in clay brick piers caused the 84-in. high piers tested to show a 10 per cent drop in strength as compared to the 40-in. high piers, whereas the concrete brick piers had approximately the same strength for both sizes.

Painted Walls

Concrete brick walls have a decided advantage where painted surfaces are desired. Cement paints properly applied and cured bond to the concrete brick and become an integral part of the surface (thereby eliminating peeling which is so often found with other brick walls). Cement paints are available in many colors and may be sprayed on the brick either before or after laying in the wall, or may be brushed into the wall surface with a stiff bristle brush. Two-tone effects are also possible, and mineral oxide pigments may be mixed integrally to give the desired color.

Newport Court Apartments, Houston, Texas. Painted concrete brick used for exterior walls. Swenson & Heidbreder, architects. Ivan H. Greer, contractor.

Additional Advantages of Concrete Brick Made with Light-Weight Aggregates

Furring strips and other wood trim may be nailed directly to light-weight concrete brick walls, thereby eliminating the expense of costly wall plugs. Nailability is obtained when light-weight aggregates such as cinders, expanded shale, or expanded slag aggregates are used in making the concrete brick.

Light-weight concrete brick also have the same distinct thermal advantages as light-weight concrete masonry units, due to the many air cells in the aggregates. An 8-in. solid brick wall made of light-weight concrete brick has a heat transmission coefficient substantially the same as an 8-in. wall of hollow light-weight concrete block made with the same aggregate. See Table 11, page 23. In other words, there is no appreciable difference between the heat transmission coefficient of hollow block walls made of light-weight aggregates and solid brick walls of the same material and thickness. The insulative value of light-weight concrete brick walls is a distinct advantage for this material in all types of building construction.

The sound absorption characteristics of exposed light-weight brick also will be substantially equal to the excellent values obtained with hollow concrete masonry units made with the same aggregates. In buildings where acoustical treatment of walls is necessary or desirable, this factor alone will result in substantial savings in wall construction costs. (See Section 11.) The sound transmission values due to the increased weight of wall will be superior to hollow concrete masonry and clay brick and tile walls of the same thickness. (See Section 12.)

Underwriters' Laboratories' Standard for Concrete Masonry Units

REQUIREMENTS FOR CONCRETE MASONRY UNITS

General

This STANDARD covers HOLLOW AND SOLID CONCRETE MASONRY UNITS which have been shown by fire tests to be eligible for fire retardant classifications under standard fire exposure conditions as specified in the American Standard Fire Test Specifications. Solid units are defined as having an average core area of not more than 25 per cent of gross volume, whereas hollow units have average core areas in excess of 25 per cent of gross volume.

This STANDARD is based upon records of tests and field experience and is subject to revision as further experience and investigations may show to be necessary or desirable.

Products which comply with this STANDARD will not necessarily be acceptable if they have other features which when examined and tested are found to impair the results contemplated by this STANDARD.

Products having materials or forms of construction differing from those detailed in this STANDARD may be examined and tested according to the intent of the STANDARD and if found to be substantially equivalent may be given recognition.

Requirements are shown in bold face type and are supplemented by explanatory notes and descriptions of test apparatus and methods in light face type.

Design

One-piece units with two or three rectangular or oval core holes and with plain or ornamental facing shall be considered as standard.

Other one-piece units may require Fire Endurance and other tests before they can be classed as Standard.

Dimensions

HEIGHT—The height of hollow and solid units shall be not more than 8 in. (nominal).

WIDTH—The width (or thickness) of hollow and solid units shall be not less than 8 in. (nominal) as laid in the wall.

LENGTH—The length of hollow and solid units shall be not more than 16 in. (nominal).

NOTE: A tolerance of ¼ in. plus or minus shall be recognized for the above dimensions, but actual dimensions shall be used in computing compressive strength values.

Cement

Standard Portland cement (A.S.T.M. specification) shall be used.

Cement-Aggregate Proportion

The cement-aggregate proportion for hollow units shall not exceed 1:7. That for solid units shall not exceed 1:6.

NOTE: The above proportions are given in terms of volumes of cement to volumes of combined dry rodded fine and coarse aggregates (after mixture).

No change shall be made in any particular cement-aggregate proportion specified until strength and other tests have been made on specimens representative of the new proportion.

At least 25 per cent by volume of the mixed aggregates, including cinders, Haydite, Waylite and Superock shall be coarse aggregate (retained on a No. 4 screen).

Face Shells (Side Walls) and Webs

Type of Unit and Aggregate	Average Minimum Face Shell and Internal Web Thicknesses (inches)								
	Class D-2 Retardants			Class C-3 Retardants			Class B-4 Retardants		
	Face Shell		Web	Face Shell		Web	Face Shell		Web
	Average	Minimum	Minimum	Average	Minimum	Minimum	Average	Minimum	Minimum
HOLLOW UNITS All Aggregates except Haydite, Superock, Waylite	1⅜	1¼	1	1¾	1½	1			
HOLLOW UNITS Haydite Aggregate	1¼	1⅛	1	1½	1⅜	1			
HOLLOW UNITS Superock and Waylite Aggregates	1¼	1⅛	1				1½	1⅜	1
SOLID UNITS* All Aggregates except Siliceous							2¼	2⅛	1½

*Volume of core space not to exceed 25 per cent.

The percentage of coarse aggregate to total mixed aggregate shall not be changed from any specified value until strength and other tests have been made on specimens representative of the new proportion. It is recommended that the coarse aggregate pass a ⅝-in. screen and that the maximum size of individual particles shall not exceed one-half the thickness of the thinnest web or shell member of the unit in which they are used.

Aggregate

This Standard covers concrete masonry units made with the following types of coarse aggregate:

1—Natural aggregates (gravel, crushed stone, etc.) containing not more than 65 per cent siliceous material
2—Blast furnace slag (unprocessed)
3—Cinders
4—Haydite
5—Waylite
6—Superock

The aggregates used, both fine and coarse, including sand, shall be secured from sources insuring uniformity in quality and kind.

Fine aggregate is defined as that passing a No. 4 screen (3/16 in.) and coarse aggregate as that retained on a No. 4 screen.

Coarse aggregates other than cinders, Haydite, Waylite and Superock shall contain not more than 65 per cent by weight of siliceous material when used in hollow units and not more than 20 per cent when used in solid units.

Aggregates containing siliceous material in excess of this amount require Fire Endurance and other tests to determine their performance under standard fire exposure conditions.

Cinders, when used as either fine or coarse aggregate or both, shall be of good quality, resulting from the combustion of coal.

When cinders are used, the average combustible content of the mixed fine and coarse aggregates shall not exceed 35 per cent by weight of the dried mixed aggregates.

NOTE: In general, acceptable results of a single analysis shall suffice to indicate compliance of a specific lot of material with this specification. In case of question as to compliance of material with the requirement, this average shall be determined by analysis of not less than three samples representative of the lot, and in no case shall an individual sample contain more than 10 per cent by weight of combustible material in excess of the specified average.

Fine and coarse Haydite aggregate, when used, shall consist of crushed clinkers resulting from the burning of crushed shale or clay. The weight of the dry rodded fine aggregate shall be not less than 50 lbs. per cu. ft. nor more than 70.5 lbs. per cu. ft. The weight of the dry rodded coarse aggregate shall be not less than 42 lbs. per cu. ft. nor more than 63.5 lbs. per cu. ft.

Fine and coarse Waylite and Superock aggregates shall consist of steam-processed slag, in the form of porous particles predominantly light buff in color, somewhat friable in character. The weight of the dry rodded fine aggregates shall be not less than 54 lbs. per cu. ft. and not more than 65 lbs. per cu. ft. The weight of the dry rodded coarse aggregates shall be not less than 36 lbs. per cu. ft. nor more than 49 lbs. per cu. ft.

Asbestos fibre, when used as an admixture, shall be added to the combined fine and coarse aggregate in a proportion of not to exceed 10 lbs. per Standard 94-lb. bag of cement.

Strength

Hollow concrete units shall have an average strength in compression of 700 lbs. per sq. in. of gross cross-sectional area as laid in the wall when tested not more than 28 days after manufacture. Individual units shall have a minimum compressive strength of 600 lbs. per sq. in. gross cross-sectional area when tested not more than 28 days after manufacture.

Solid concrete units shall have an average strength in compression of 1800 lbs. per sq. in. gross area as laid in the wall when tested not more than 28 days after manufacture. Individual units shall have a minimum compressive strength of 1600 lbs. per sq. in. gross cross-sectional area when tested not more than 28 days after manufacture.

The procedure in making tests for compressive strength shall agree with the standard specifications of the American Society for Testing Materials.

Consistency

The concrete used in the manufacture of hollow or solid units may be of a dry, damp, wet damp or wet consistency.

No change in an established practice as to the consistency of the material shall be made until strength and other tests have been made on specimens representative of the new consistency.

Curing Methods

Hollow and solid units may be air, water or steam cured. Water or steam curing is preferred due to the resultant uniformity of strength and other characteristics.

All units shall be held in storage for a period of not less than 28 days (including curing period) unless strength and other tests have indicated compliance with the standard of units shipped prior to that time. In cases where units are shipped before 28 days, steam or water curing is considered essential.

NOTE: It is recommended that in all cases units be held in storage for at least 10 days after manufacture.

Fire Endurance Tests

When Fire Endurance Tests are made on units not clearly conforming to all of the specifications of this Standard, to determine their eligibility for classification and listing, the program of the American Standard Fire Test Specification shall be followed, except that panels may be not more than 6x6-ft. exposed areas and the Fire Hose Stream Test may be omitted, if, in the judgment of the testing body, the data secured therefrom are not required to confirm or supplement that secured in the Fire Endurance Test.

Suggested Specifications for Concrete Footings and Concrete Masonry Walls

The information presented herein is in condensed form with the thought that it might be of assistance to architects and builders in preparing specifications. It is expected that such changes will be made in the specifications as to make them apply to the particular job for which they are written. The accompanying illustrations are for the purpose of clarifying details referred to. They are not intended as part of suggested specifications.

GENERAL DISCUSSION

In recent years the employment of concrete masonry for all classes of buildings has forged to the front because of such inherent advantages as appearance, economy, ruggedness, firesafety, adaptability to all types of masonry wall construction and its general availability. As with other types of construction, optimum results are secured with concrete masonry by using units of uniformly high quality, laid with careful workmanship. It is of special importance in all types of masonry construction to seal the wall against possible entrance of moisture through

—close attention to filling and tooling the mortar joints;

—proper application of approved flashing; and

—the sealing of all exposed wall surfaces by the proper application of portland cement stucco or a portland cement base paint.

SUGGESTED SPECIFICATIONS

I. General

1. The masonry contractor shall provide all materials and equipment required to complete the concrete footings and the concrete masonry walls (basement walls, exterior walls, partition walls, etc.) of this project in accordance with the plans and specifications. The work shall be properly coordinated with that of other trades. All local laws and ordinances applicable to this work shall be fully complied with.

II. Materials

1. Concrete masonry units shall conform to the physical requirements (compressive strength, absorption and moisture content) of the local building code. In the absence of a local building code the current A.S. T.M. specifications covering the particular use or construction in which they are employed shall apply. Concrete masonry units shall be in a dry condition when delivered to the building site and shall be protected against wetting prior to laying in the walls.

2. Concrete for the manufacture of sills, coping, etc., shall have a minimum compressive strength of 4,000 p.s.i. at 28 days.

3. Concrete for reinforced concrete lintels shall have a minimum compressive strength of 2,000 p.s.i. at 28 days.

4. Portland cement and lime shall comply with current A.S.T.M. specifications for these materials.

5. Mortar sand shall be well graded with all the material passing a No. 8 sieve, and not more than 20 per cent passing a No. 50, or more than 5 per cent passing the No. 100 sieve.

(NOTE: The use of very fine mortar sands will result in weaker mortars because of higher water requirements for a satisfactory plasticity. The use of richer mixes to overcome deficiency in sand grading and to maintain strength is not desirable.)

Abstracts from A.S.T.M. Specifications

(Complete specifications are available from American Society for Testing Materials, Philadelphia.)

Minimum Face-Shell Thickness	Compressive Strength p.s.i. Based on Gross Area: Mean of Five Tests	Compressive Strength p.s.i. Based on Gross Area: Individual Minimum	Absorption	Moisture Content
For Hollow Load-Bearing Concrete Masonry Units (A.S.T.M. Designation C90-39)				
1¼ in. or over	700	600	*Not to exceed 15 lb. per cu.ft. of concrete	Not to exceed 40% of total absorption
¾ in. to 1¼ in.	1000	800	Ditto	Ditto
For Solid Load-Bearing Concrete Masonry Units (A.S.T.M. Designation C145-39T)**				
Not specified. See note**	GRADE A: 1800	GRADE A: 1600	*Not to exceed 15 lb. of water per cu.ft. of concrete	Not to exceed 40% of total absorption
	GRADE B: 1200	GRADE B: 1000	Ditto	Ditto
For Hollow Non-Load-Bearing Concrete Masonry Units (A.S.T.M. Designation C129-39)				
Not less than ½ in.	350 or over	300	Not specified	Not over 40% of total absorption

For Concrete Building Brick (A.S.T.M. Designation C55-37)

	Compressive Strength p.s.i. (Brick flatwise) Based on Mean Gross Area		Modulus of Rupture p.s.i. (Brick flatwise)	
	Mean of Five Tests	**Individual Minimum**	**Mean of Five Tests**	**Individual Minimum**
GRADE A	2500 or over	2000	450 or over	300
GRADE B	1250 to 2500	1000	300 to 450	200

*Units which are not exposed to weather or soil in finished work need not conform to absorption requirements.

**Units with 75% or more net area.

6. Fine and coarse aggregates for cast-in-place footings shall be uniformly graded and shall comply with the current A.S.T.M. specifications for these materials when used for concrete. Maximum size of coarse aggregate shall be 1½ in.

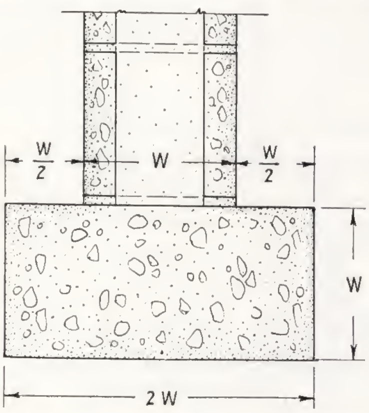
7. Water shall be clean and fit to drink.

III. Cast-In-Place Concrete Footings

1. Cast-in-place concrete footings shall be built to dimensions shown on plans. They shall be cast in forms true to line and elevation.

2. All footings shall be cast on undisturbed solid earth. In the event excavation is carried below the required grade, the depth of footings shall be increased.

3. Concrete for footings shall be machine-mixed in the approximate proportions of 1 volume of portland cement to 2½ volumes of sand and 3½ volumes of gravel or crushed stone (1:2½:3½ mix). Not more than 6 gal. of water per sack of cement shall be used.



Typical design for cast-in-place concrete footing supporting concrete masonry bearing wall.

(NOTE: General practice is to build footings having a depth equal to the thickness of foundation wall and 8 in. wider than the wall resting on the footing. Where soil conditions do not provide good bearing it is desirable to spread the footings over more area and to add longitudinal steel reinforcement according to local building code requirements.)

IV. Concrete Masonry Wall Construction

1. All masonry walls shall be true and plumb and built to the thickness and to the bond or pattern indicated on the plans. Where no bond or pattern is indicated the wall shall be laid in straight uniform courses with the units in the courses above regularly breaking joints with the courses below. All workmanship shall be of the highest grade.

2. Masonry contractor shall provide and place such special units (corner block, door and window jamb block, fillers, veneer block, etc.) as may be required to form all corners, returns and offsets using the required shapes and sizes to work to corners and openings and maintain a proper bond throughout the length of the wall.

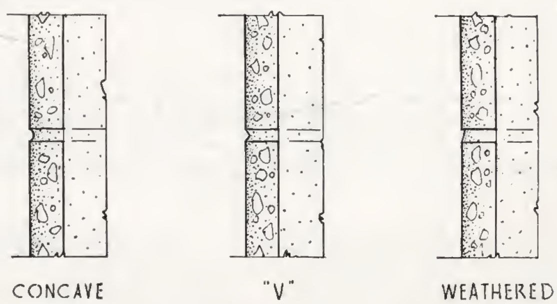
3. Where interior concrete masonry partitions meet other interior partitions or meet exterior walls, a firm bond shall be provided with masonry or approved metal ties.

4. Mortar joints shall be not more than ½ in. thick with full mortar coverage on vertical and horizontal face shells. Vertical joints shall be shoved tight.

Example of face-shell bedding.

Concrete Masonry Walls to be Exposed or Painted

5. Mortar joints shall be struck off flush with wall surface and when partially set shall be compressed and compacted with a rounded or V-shaped tool.



Approved types of tooled mortar joints.

(NOTE: An attractive treatment, frequently used, is obtained by emphasizing the horizontal joints and obscuring the vertical joints in concrete ashlar walls. This is done by tooling the horizontal joints and striking the vertical joints flush with the wall surface. When this is desired, the architect may substitute the following for Paragraph 4 above: "Vertical mortar joints shall be troweled flush and rubbed with carpet or burlap to remove sheen from troweled mortar surface. Horizontal joints shall be struck flush with wall surface and when partially set shall be compressed and compacted with a pointing tool.")

Concrete masonry wall in which horizontal mortar joints have been emphasized by tooling and vertical joints obscured by striking flush and rubbing.

Concrete Masonry Wall to Be Plastered, Stuccoed or Used as Back-up

6. Mortar joints shall be struck flush with the face of the wall.

Below-Grade Construction

7. In construction below grade or where walls come in contact with earth or other fill, concrete masonry shall be laid in a portland cement mortar consisting of 1 volume of portland cement and not more than 3 volumes of damp, loose mortar sand (1:3 mix) to which plasticizing agents may be added.

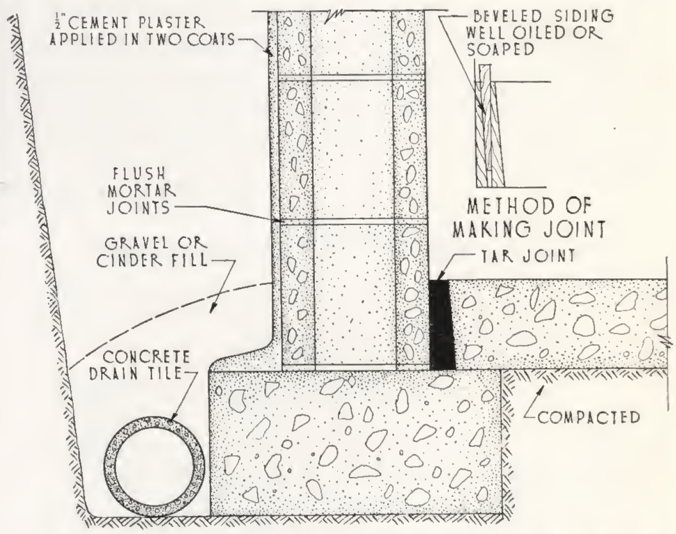
(NOTE: The amount of plasticizing agent required will vary with the kind of agent used, the grading of the sand, and other factors. Use the minimum quantity which will produce the required workability. The kind of plasticizing agent to be used and the amount should be specified by the architect or owner in advance of starting construction.)

8. Face-shell bedding shall be used with complete coverage of face shells. Furrowing of the mortar shall not be permitted. Extruded mortar shall be cut off flush with face of wall and the joints firmly compacted, after the mortar has stiffened somewhat, with a rounded tool having a diameter slightly larger than the thickness of the joint (tooling of joint may be omitted where walls are to be plastered). Mortar joints shall be not more than ½ in. thick. Backfilling of foundation walls will not be permitted until first floor is in place.

(NOTE: Tooling is essential in producing tight mortar joints. Mortar has a tendency to shrink slightly and may pull away from the edges of the masonry units causing fine, almost invisible cracks at the junction of mortar and masonry units. Tooling compacts the mortar and presses it firmly against the units, increasing the water-resistance of the joint. It should be done after the mortar has partially set.)

SUPPLEMENT FOR WET SOIL CONDITIONS:

A. The earth side of concrete masonry basement walls shall be parged with portland cement plaster applied in two coats, each coat ¼ in. thick. Plaster shall consist of 1 volume of portland cement and 2½ volumes of mortar sand (1:2½ mix) with the addition of enough water to produce a plastic mix. Wall surface shall be moistened prior to application of first coat. First coat shall be roughened after it has partially set and then be permitted to harden for 24 hours before the second coat is applied. The first coat shall be moistened prior to application of second coat. At the junction of the outside wall face and the footing, the cement plaster shall be thickened and rounded to form a cove to divert water from the base of the wall. No filling in against foundation walls shall be allowed until first floor is in place and plaster has hardened sufficiently to prevent damage.



Suggested construction of exterior basement wall for wet soil conditions.

B. Where shown on plans, 4-in. diameter concrete drain tile shall be laid with open joints around the footing and drained to a suitable outlet with a slope of ½ in. in 12 ft. In no case shall the tile be lower than the footing. Joints between the tile shall be covered with pieces of roofing felt to prevent sediment filling the tile during backfilling. The excavation outside the walls shall be filled with gravel or crushed rock or cinders to a depth of at least 18 in. Earth backfill above shall be sloped away from foundation walls to provide drainage from foundation.

Above-Grade Construction

9. Concrete masonry walls above grade shall be laid with portland cement-lime mortar consisting of 1 volume of portland cement, not more than 1 volume of lime putty or hydrated lime and damp, loose mortar sand equal to not more than three times the combined volumes of cement and lime. Enough water shall be added to produce, after thorough mixing, a mortar of good working consistency.

(NOTE: The plasticity and workability of mortar can be improved by hoeing it over in the mortar box from time to time. It is customary practice to mix only as much mortar at one time as can be used in two to three hours.)

ALTERNATE FOR MASONRY CEMENT MORTAR IN ABOVE-GRADE CONSTRUCTION:

A. Concrete masonry walls above grade shall be laid in masonry cement mortar consisting of 1 volume of masonry cement meeting the requirements for Type II of Federal Master Specifications SS-C-1816, and not more than 3 volumes of damp, loose mortar sand (1:3 mix). Enough water shall be added to produce, after thorough mixing, a mortar of good working consistency.

V. Courses Supporting Floors

Floors Having Continuous Bearing on Wall

1. Where floors have a continuous bearing on the walls, the cores in the course of masonry which will carry the floor shall be filled with mortar of the same quality as used for laying the wall.

Floors Supported on Joists Bearing on Wall

2. All cores occurring immediately below joists in the course of concrete masonry which carries the floor shall be filled with mortar of the same quality as used for laying the wall.

ALTERNATE FOR PARAGRAPHS 1 OR 2 ABOVE:

A. The course of masonry supporting floor construction shall be of solid concrete masonry units and shall be not less than 4 in. in height.

3. Masonry contractor shall provide and place filler units between joists as detailed on the plans, using mortar of the same quality as used in laying the wall. A clear space of at least ½ in. shall be provided between the outer edge of floor and the veneer block used in the wall facing.

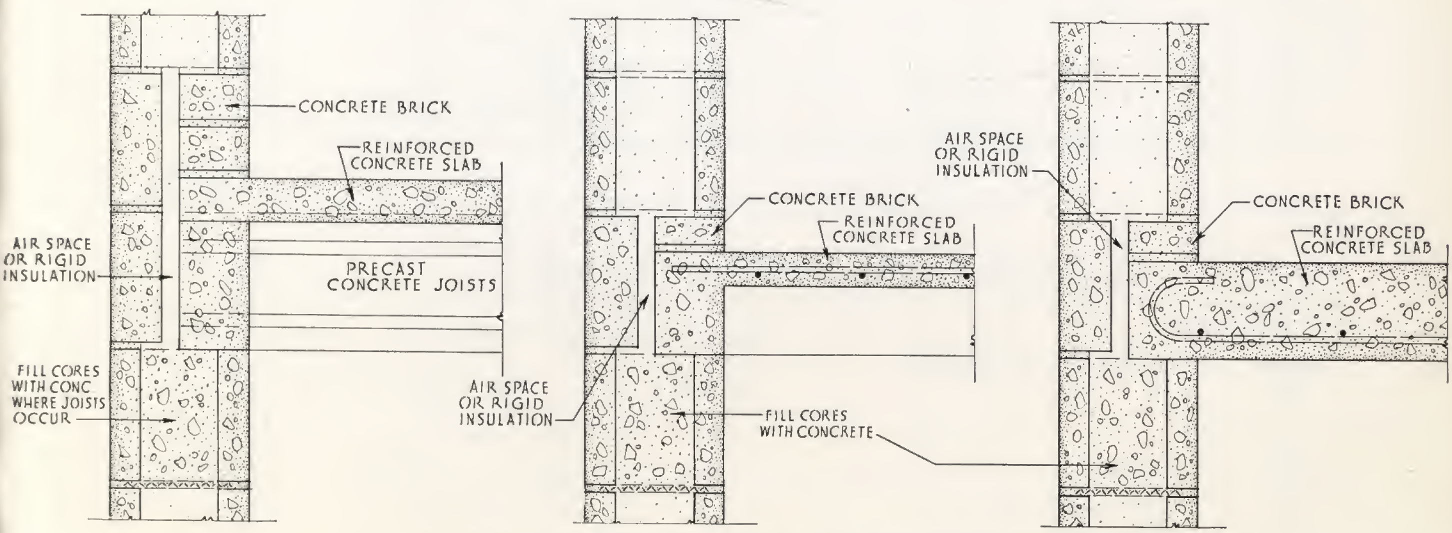
VI. Attachment for Wood Sills and Plates

1. Masonry contractor shall furnish and set ½x18-in. bolts at 4-ft. centers for attachment of sills and plates as detailed on the plans. Bolts shall be set in the cores of the concrete masonry units and such cores shall be filled solid with mortar of the same quality as used in laying the wall. The threaded ends of the bolts shall project above the top course of masonry a sufficient distance to secure plates or sills thereto as shown on plans.

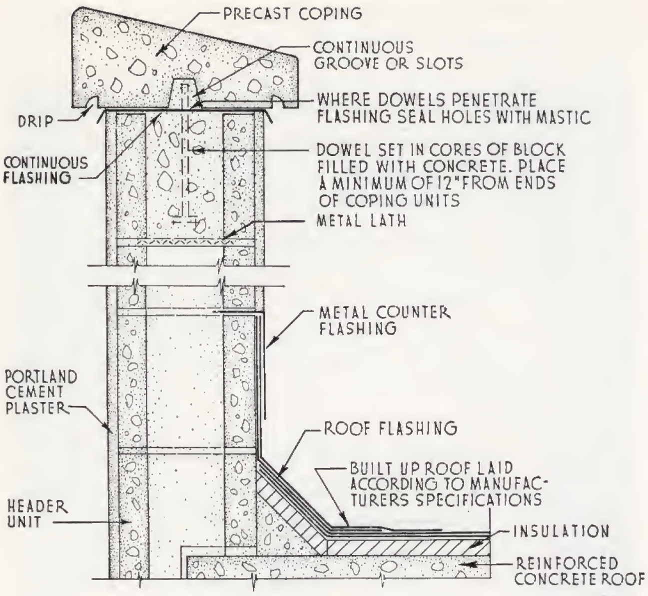
VII. Coping and Parapet Walls

1. Contractor shall provide and place coping and parapet walls as detailed on the plans.

2. Flashings shall extend entirely across the top of the wall under the coping. All joints in flashing shall be soldered and watertight. Coping units shall be attached to masonry wall with dowels as shown on plans. Dowels shall be placed at least 12 in. from joints in coping. Holes in flashing where dowels penetrate shall be made



Typical floor bearing details with concrete masonry walls.



Typical coping detail.

watertight by an application of mastic waterproofing compound after flashing is in place.

3. Construction at junction of parapet wall and roof shall be as detailed on plans with counterflashing embedded in the masonry walls at the time they are laid. All exposed masonry wall surfaces on the inside (roof side) of the parapet wall shall be given the same surface application (portland cement paint or stucco) as the outside wall surface.

VIII. Concrete Sills and Lintels

1. Contractor shall furnish and place reinforced concrete lintels over all door and window openings. They shall be of type and dimensions shown on plans. They shall be firmly bedded in mortar of the same quality as used in laying the wall. Lintel reinforcement shall conform to the lintel reinforcement schedule shown on plans. Top of lintel shall be marked as such.

2. Concrete lintels shall be of same material and texture as the wall in which they are to be built.

(NOTE: The following design tables for reinforced concrete lintels are included for the convenience of the architect, builder and products manufacturer.

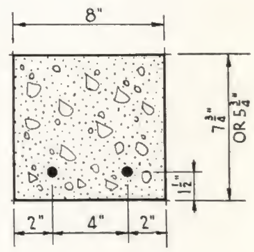
It should be noted that Tables A and B are for lintels supporting wall loads only. Table C is for lintels supporting both wall and floor loads. To simplify the latter table, the floor load was assumed to be 85 lb. per sq.ft. including both live and dead loads and the span of the floor was assumed to be 20 ft. This is equivalent to a total floor load of 850 lb. per lin.ft. of lintel and should be ample for most cases.

It should be noted that stirrups are not required in Tables A and B but are required in Table C with the exception of the 3-ft. span. All stirrups are designed for No. 6 gage wire and may be formed as illustrated.

While not necessary in all cases, an 8-in. bearing is recommended for all lintels. The advantages of an 8-in. bearing are twofold: first, it will not require the use of a special block size to fit at the ends of the lintel; and second, it will make the lintel more effective in transferring stresses across the opening.)

TABLE A—LINTELS WITH WALL LOAD ONLY

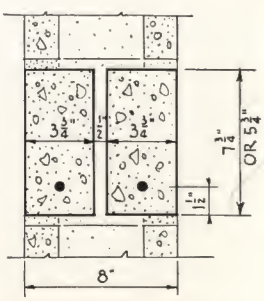
Size of lintel		Clear span of lintel ft.	Bottom reinforcement	
Height in.	Width in.		No. bars	Size of bars
5¾	8	Up to 7	2	⅜-in. round deformed
5¾	8	7 to 8	2	½-in. round deformed
7¾	8	Up to 8	2	⅜-in. round deformed
7¾	8	8 to 10	2	½-in. round deformed



One-piece lintel (see Table A).

TABLE B—SPLIT LINTELS WITH WALL LOAD ONLY

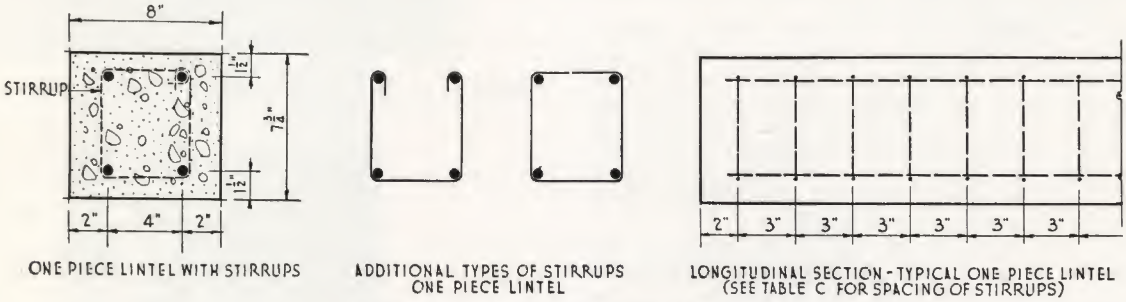
Size of lintel		Clear span of lintel ft.	Bottom reinforcement—each section	
Height in.	Width in.		No. bars	Size of bars
5¾	3¾	Up to 7	1	⅜-in. round deformed
5¾	3¾	7 to 8	1	½-in. round deformed
7¾	3¾	Up to 8	1	⅜-in. round deformed
7¾	3¾	8 to 10	1	½-in. round deformed



Split lintels (see Table B).

TABLE C—LINTELS WITH WALL AND FLOOR LOADS
(Floor load assumed to be 85 lb. per sq.ft. with 20-ft. span)

Size of lintel		Clear span of lintel ft.	Reinforcement		Web reinforcement No. 6 gage wire stirrups. Spacings from end of lintel—both ends the same
Height in.	Width in.		Top	Bottom	
7¾	8	3	None	2—⅜-in. round	No stirrups required
7¾	8	4	2—⅜-in. round	2—½-in. round	3 stirrups, Sp.: 2, 3, 3 in.
7¾	8	5	2—⅜-in. round	2—⅝-in. round	5 stirrups, Sp.: 2, 3, 3, 3, 3 in.
7¾	8	6	2—¾-in. round	2—¾-in. round	7 stirrups, Sp.: 2, 3, 3, 3, 3, 3, 3 in.
7¾	8	7	2— 1-in. round	2— 1-in. round	9 stirrups, Sp.: 2, 3, 3, 3, 3, 3, 3, 3, 3 in.



Typical one-piece lintel (see Table C).

ALTERNATE FOR LINTELS:

A. Where shown on plans, lintels shall consist of steel angles as detailed.

Slip Sills

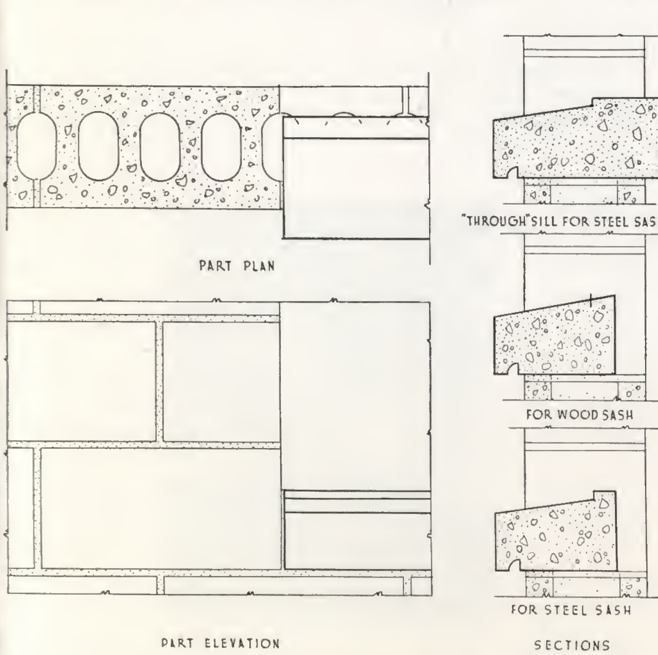
3. Contractor shall furnish and install precast concrete sills of size, dimension and finish shown on scale drawings for all door and window openings.

4. Sills shall be set level in accordance with scale drawings with full mortar bedding. Head joints shall be packed tight and pointed after mortar has partially hardened.

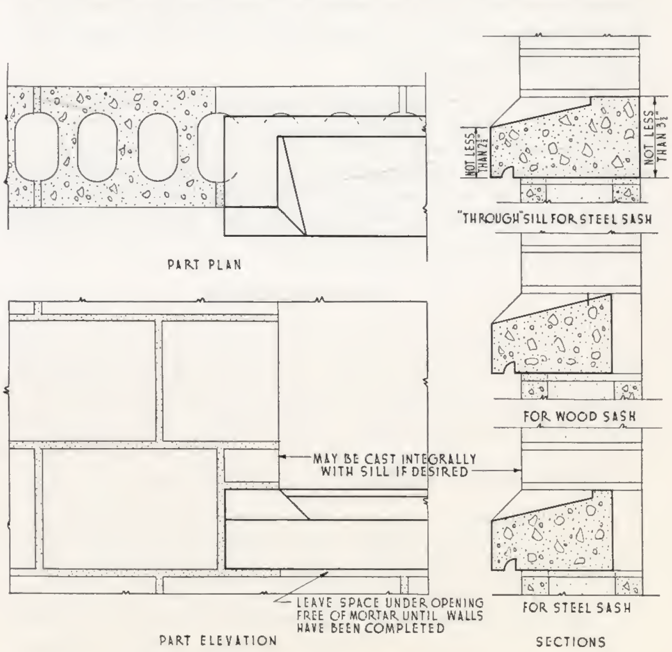
ALTERNATE FOR PARAGRAPH 4 ABOVE:

Lug Sills

A. Sills shall be set in accordance with scale drawings as walls are laid up. Only the ends of the sills projecting into the wall shall be set in mortar. After



Typical slip sill details.



Typical lug sill details.

the walls are completed the balance of the sill shall be bedded by filling and pointing from both sides.

(NOTE: Sills serve the purpose of providing watertight bases at the bottom of wall openings. Made in one piece, there are no joints for possible leakage of water into wall below. They are sloped on top face to drain water away quickly. They are usually made to project 1½ to 2 in. beyond wall face and are made with a groove along the lower outer edge to provide a drip so that water draining off the sill will fall free and not flow over the face of the wall, causing possible staining.

Slip sills are popular because they can be inserted after the wall proper has been built and therefore require no protection during construction. Since there is an exposed joint at each end of the sill, special care should be taken to see that it is completely filled with mortar and the joints packed tight.

Lug sills are so called because they project into the masonry wall (usually 4 in. at each end) the projecting parts being termed the "lugs". There are no vertical mortar joints at the juncture of the sills and the jambs. Like the slip sill, lug sills are usually made to project from 1½ to 2 in. over the face of the wall and are provided with a groove under the lower outer edge to form a drip. Frequently they are made with washes at either end to divert water away from the juncture of the sills and the jambs. This is in addition to the outward slope on the sills.

At the time lug sills are set, only the portion projecting into the wall is bedded in mortar. The portion immediately below the wall opening is left free of contact with the wall below. This is done so that in case there is minor settlement or adjustments in the masonry work during construction the sill will be freer to adapt itself to such minor wall movements, thus avoiding possible damage to the sill during the construction period. The space between the sill and the wall below is filled with mortar and pointed after the exterior walls have been built.)

5. Sills shall be protected against injury or staining during construction. This protection shall be removed at the time the wall is cleaned.

IX. Flashing

1. Masonry contractor shall provide and place all flashing as detailed on plans. Flashing shall consist of No. 26 gage (14 oz.) copper sheets or other approved non-corrodible material.

(NOTE: Adequate flashing with rust and corrosion-resisting material is of the utmost importance because it prevents water from getting through the wall at vulnerable points. Points requiring protection by flashing are: tops and sides of projecting trim; under coping and sills; at intersections of wall and roof; under built-in gutters; at intersections of chimney and roof; and at other points where moisture is likely to gain entrance.)

X. Cleaning Walls

1. At conclusion of masonry work, contractor shall clean down the walls, remove all scaffolding and equipment used in the work, clean up all debris and refuse and surplus material and remove same from premises.

SUPPLEMENTS—SELECT AS APPLICABLE TO JOB:

A—Chases. Chases for heating, plumbing and electrical ducts, pipes and conduits shall be built into concrete masonry walls as detailed on plans.

B—Fill Insulation. Masonry contractor shall fill cores of hollow concrete masonry units in all outside walls with granulated insulation as construction proceeds. Filling shall be done when walls reach the sill line, lintel line and floor line. Granulated insulation shall be .... as manufactured by ....

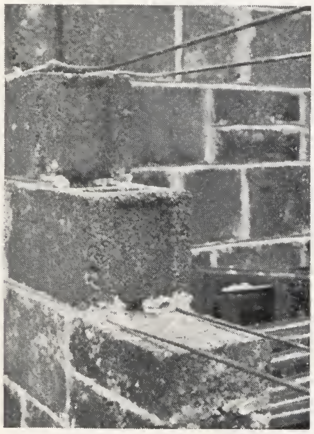
View of electrical outlet box in concrete masonry wall.

View showing rigid conduit or pipes in cores of hollow concrete masonry wall.

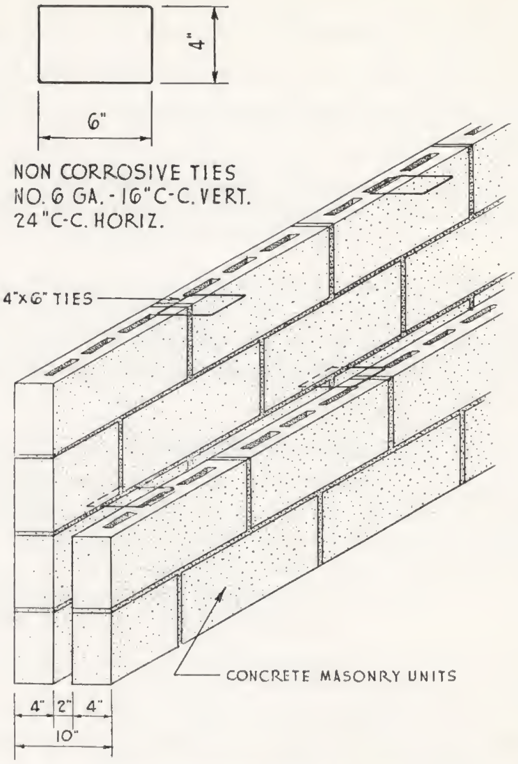
Filling cores of hollow concrete masonry units with granular insulation.

C—Furring Ties. Crimped galvanized metal inserts of approved type for attachment of furring strips shall be placed in mortar joints as work progresses. They shall be spaced 24 in. vertically and 16 in. horizontally.

D—Wall Reinforcement. Masonry contractor shall furnish and place ¼-in. round steel reinforcing rods in horizontal mortar joints as detailed on plans.



View showing use of ¼-in. bars in concrete masonry wall construction.



Hollow double concrete masonry wall construction.

(NOTE: Common practice is to place two rods, one in each face shell joint in alternate courses above and below window openings. Rods should also be carried over door openings and should be bent around corners. Bars are lapped a minimum of 10 in.)

E—Concrete Masonry Backing. Concrete masonry backing shall be bonded with header courses of the facing material as detailed on the plans.

(NOTE: Usual requirement for masonry bond is that every sixth course be a header course or that one full header be used for each 72 sq. in. of wall surface.)

F—Concrete Masonry Veneer. Facing shall be tied to concrete masonry backing with approved rust-resisting metal ties, spaced at not more than .... in. horizontally and .... in. vertically.

(NOTE: For metal ties the common requirement is that ties be spaced at 16 in. vertically and not more than 26 in. horizontally.)

G—Hollow Double Walls. Hollow double walls consisting of an interior wall .... in. thick and an exterior wall .... in. thick separated by a 2-in. air space shall be built as shown on plans. The interior and exterior walls shall be tied together with approved metal ties.

(NOTE: FHA approves hollow concrete masonry wall construction consisting of two 4-in. hollow concrete masonry walls separated by a 2-in. air space and tied with a closed rectangular tie of No. 6 gage rust-resisting or rust-protected wire spaced 24 in. horizontally and 16 in. vertically.)

XI. Concrete Masonry Chimneys

Lined Chimneys

1. Contractor shall line chimney throughout with fire clay flue lining as shown on plans. Minimum flue sizes shall be 8½ in. x 8½ in. for heating plants; and 8½ in. x 13 in. for fireplaces. Circular flues of equivalent area may be substituted if desired.

(NOTE: When two flues are contained in a chimney, the joints of the adjoining sections of flue linings should be staggered at least 7 in. Where there are more than two flues in a chimney, at least every third flue should be separated by masonry at least 3¾ in. thick, bonded into the masonry wall of the chimney. Masonry should be at least 8 in. thick on the exposed sides of chimneys built into exterior walls.)

Unlined Chimneys

2. Unlined chimneys shall be built of solid masonry at least 8 in. thick. Units shall be laid and mortar struck off or pointed in such a manner as to produce a smooth inside wall surface.

3. All chimneys shall be capped as detailed on the plans. Chimney caps shall be manufactured of concrete having a minimum compressive strength of 4,000 p.s.i. at age of 28 days. They shall be provided with a wash to the outside edge of the cap and shall be made to project not less than 1½ in. over the outside chimney

face, with a groove along the lower outer edge to provide a drip. The chimney cap shall not decrease the required flue area.

4. All chimneys shall extend at least .... ft. above the highest ridge.

(NOTE: Usual requirements are that the chimney project at least 2 ft. above the highest ridge for pitched roof construction or not less than 3 ft. above the roof deck for flat roof construction.)

5. Flashing shall be provided at all points where chimney penetrates the roof as detailed on the plans. Flashing shall consist of No. 26 gage (14 oz.) copper sheets or other approved non-corrodible material.

XII. Fireplaces

1. Contractor shall build fireplace and mantel of materials, dimensions and type as detailed on the plans.

2. Contractor shall build hearth of ....(state material and finish) as manufactured by ...., or equal. Hearth shall be laid in the pattern and to the dimensions detailed on the plans.

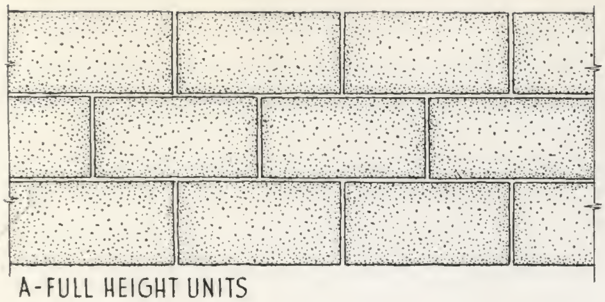
(NOTE: Where hearth is to be built of precast units such as concrete tile, clay tile, slate, etc., add the following to above: " .... (*name of material*) shall be laid in strict accordance with the manufacturer's recommendations".

Hearths are usually made to project about 16 in. in front of fireplace opening and at least 8 in. beyond on each side. The hearth may consist of a colored concrete topping marked off into squares or other geometric patterns. The Portland Cement Association publication, *Suggested Specifications for Applying Finishes and Coverings on Concrete Residence Floors*, describes methods of building colored concrete toppings. A copy is available free on request.)

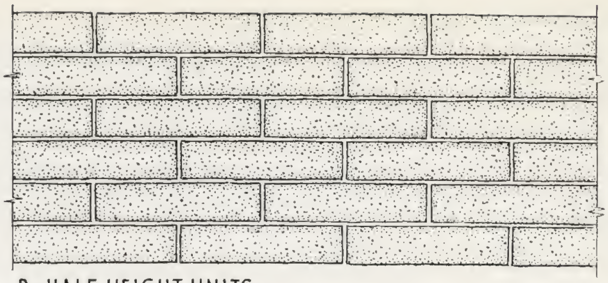
3. Fireplaces shall be built with smoke chambers and dampers as detailed on plans. They shall be lined with fire brick or other material approved by the architect. Fire brick shall be laid up in a fire clay mortar.

(NOTE: The open area of the flue should be not less than 1/12 the area of the fireplace opening.)

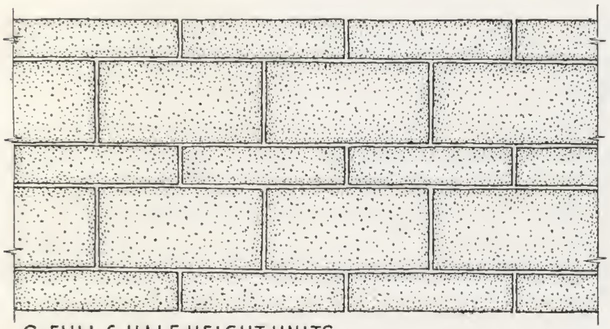
4. Ash dump shall empty into an enclosed chamber of fireproof material, provided with a metal clean-out door as detailed on plans.



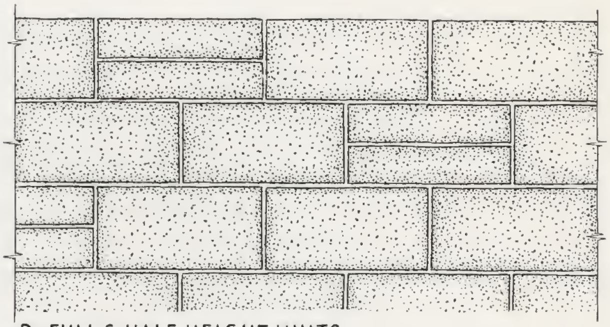
A-FULL HEIGHT UNITS



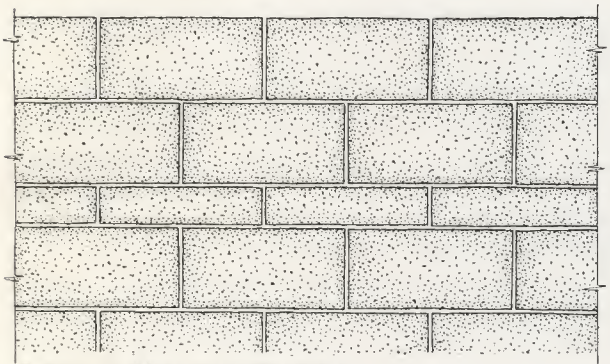
B-HALF HEIGHT UNITS



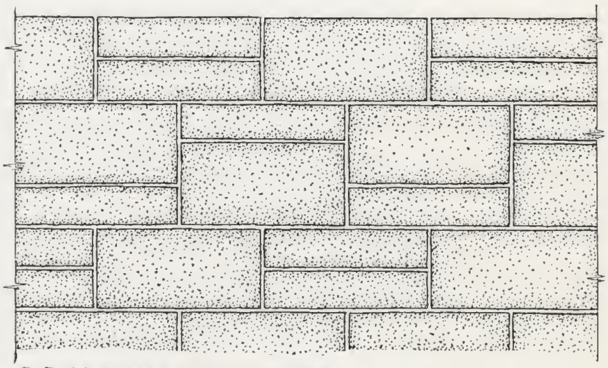
C-FULL & HALF HEIGHT UNITS



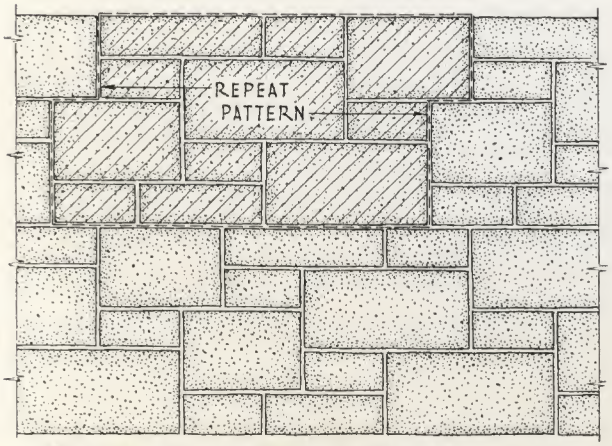
D-FULL & HALF HEIGHT UNITS



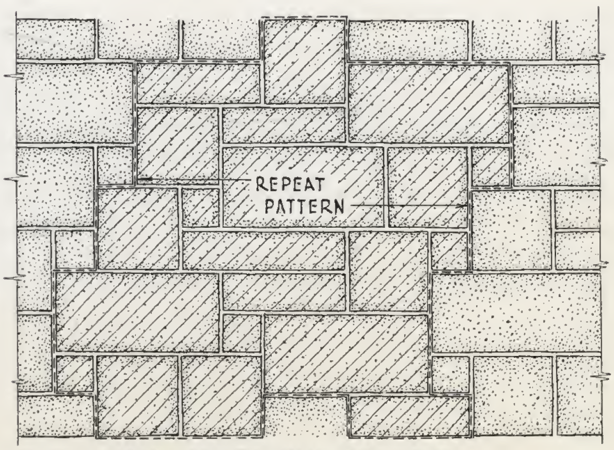
E-FULL & HALF HEIGHT UNITS



F-FULL & HALF HEIGHT UNITS



G-FULL, HALF & FRACTIONAL SIZE UNITS



H-FULL, HALF & FRACTIONAL SIZE UNITS

THE ABOVE PATTERNS CAN BE PRODUCED WITH STANDARD UNITS-8"x16" FACE, 5"x12" FACE AND 3¾"x12" FACE IN USUAL WALL THICKNESSES. MANY OTHER ATTRACTIVE PATTERNS MAY BE WORKED OUT BY THE ARCHITECT.

Several of the attractive patterns possible with concrete masonry construction.

Reference Index

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- **Hollow Non-Load-Bearing Concrete Masonry Units (C129-39)**
- **Solid Load-Bearing Units (C145-39T)**
- **Catch-Basin and Manhole Block (C139-39)**
- **Concrete Building Brick (C55-37)**
- **Standard Methods for Sampling and Testing Concrete Masonry Units (C140-39)**

Underwriters' Laboratories' Publications:**
- **Standard for Hollow Concrete Block.** (Published in full in Section 22 of this manual.)
- **Fire Retardant Report 2590 on 8-in. Bearing Walls of Hollow Concrete Block of "Superock" and "Waylite" Aggregates (1½-in. Face Shells)**
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- **No. 14—Recommended Minimum Requirements for Fire Resistance in Buildings**
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- **BMS22—Structural Properties of "Dun-Ti-Stone" Wall Construction**
- **BMS32—Structural Properties of Two Brick-Concrete-Block Wall Constructions and a Concrete-Block Wall Construction**

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*Copies available from Superintendent of Documents, Government Printing Office, Washington, D. C.

**Single copies available free from Portland Cement Association, Chicago, Illinois.

†Copies available from American Society for Testing Materials, 260 S. Broad Street, Philadelphia, Pa.

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